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HENRY HORNER, Governor

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LIST OF SPEAKERS

A committee designated by the Council of the Academy has prepared a list of speakers who are willing to present talks on various phases of science before interested groups. Unless otherwise indicated, these speakers are willing to give their services for expenses only. In some cases a small honorarium is expected. A copy of this list of speakers may be obtained gratis by sending a request to:

ROBERT F. PATON, *Secretary*,
Academy of Science,
Physics Building,
Urbana, Illinois.

PAPERS IN AGRICULTURE

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Agriculture Section carried five papers, three of which are here represented. The others were:

Peach Breeding, by M. J. Dorsey, University of Illinois, Urbana.
Heredity Resistance to Pullorum Disease in the Domestic Fowl, by Elmer Roberts, University of Illinois, Urbana.

Average attendance was twelve.

Chairman of the Agriculture Section of the 1939 meeting was elected: G. H. Dungan, 603 Old Agriculture Building, University of Illinois, Urbana, Illinois.

(Signed) E. ROBERTS, *Chairman.*

The Trailing Wild Bean in Southern Illinois

C. J. Badger

University of Illinois, Urbana, Illinois

The trailing wild bean is a member of the Fabacea or pea family. Britton and Brown in Vol. II, "The Flora of the United States, Canada and the British Possessions," describe in detail a number of species of this genus. At the present time there are not at hand sufficient data to determine definitely which of these rather numerous species prevail in southern Illinois or to say which one of the several species is the most commonly found in this region. This work deals with one of the species of the trailing wild bean. While this apparently was one of the species commonly seen in this region, no attempt was made to determine the particular species to which it belonged.

Most observations indicate that the trailing wild bean grows almost entirely in the wild state. It has been observed growing in level fields, pastures and on land out of cultivation, on hillsides, roadways, and at the edge of timber lands. It seems to do well on soils which are acid, and grows chiefly during the warm weather from July to early fall.

TABLE I—DRY MATTER AND CHEMICAL COMPOSITION OF TRAILING WILD BEAN COMPARED WITH ALFALFA

	Dry matter lbs./A	Nitrogen		Phosphorus		Potassium		Calcium		Magnesium	
		%	lbs./A	%	lbs./A	%	lbs./A	%	lbs./A	%	lbs./A
Trailing wild bean	1,550	2.43	376.7	.19	2.9	1.11	17.2	1.12	17.4	.24	3.7
Alfalfa	1,550	2.45	379.8	.23	3.6	.83	12.9	1.98	30.7	.39	6.0

The trailing wild bean may prove of value for economic utilization as a pasture plant or hay crop. Cattle relish the plant both as green forage and as dry hay. Horses also eat it readily. Belonging to the legume family the plant should have considerable value for soil improvement purposes, although there is no experimental evidence available along this line.

Some yield measurements were made during September, 1934, of the trailing wild bean grown on untreated soil on the Sparta experiment field, Randolph county, which indicate a probable yield of 1,550 pounds an acre of air-dry hay. The chemical composition of the air-dry hay reported in Table I indicates that the trailing wild bean is somewhat comparable with alfalfa produced on the Raleigh experiment field in Saline county. The total nitrogen content of the wild bean hay was almost identical with that of the alfalfa. The phosphorus content of the alfalfa hay was higher probably because it was grown on soil which had been heavily treated with rock phosphate. Similarly, the calcium and magnesium content of the alfalfa was higher probably also because of the large amount of limestone added to the soil in order to prepare it for the growing of alfalfa.

The soil on the Sparta experiment field where the trailing wild bean apparently flourished was in a relatively low state of fertility. This soil was very acid having a pH of 4.5 which indicates a very high lime requirement. The total nitrogen content of this soil was 1,100 pounds an acre compared to 3,000 to 5,000 pounds an acre for the most productive soils. The available phosphorus and available potassium content of this soil was also extremely low.

Changes in Size of Rural Families

D. E. Lindstrom

University of Illinois, Urbana, Illinois

Rural families have been becoming smaller each decade for at least the last 50 years. Farm families averaged 4.2 persons in 1930 according to the 1930 census; ten years earlier farm families averaged 4.4 persons. This trend downward is not limited to farm families; all families in Illinois decreased from 4.2 in 1920 to 3.9 in 1930; indeed, in 1890 there were 4.9 persons per family in Illinois.

Farm life is supposed to be conducive to large families; city life has always discouraged large families. Family labor has usually been considered an important factor in the earning of a living on the farm, but in the city a large family is an economic liability. With modernization in agriculture, however, and the spread of the urban influence, farm family sizes are on the downward trend.

Size of family is directly related to population increase. Families are so small in cities now that they do not maintain the population. Population analysts have computed that it takes 370 children under 5 years of age per 1,000 women 15 to 44 years of age to maintain the population. In 1930 the seven cities of Portland, San Francisco, Los Angeles, Kansas City, St. Louis, Nashville, and Atlanta, all largely of American stock, lacked about 40 per cent of having enough children to maintain their population stationary without accession from the outside, and all cities of over 100,000 population had a deficit of nearly 20 per cent, while the smaller cities had a deficit of about 7 per cent. On the other hand, the rural non-farm (mostly village and suburban) population had a surplus of over 25 per cent and the farm population of nearly 50 per cent. In 1932 urban deficit and rural surplus about balanced.[1]

In Illinois, Lake, Cook, Boone, Winnebago, Stephenson, Carroll, DeKalb, Kane, DuPage, Will, Kankakee, Lee, Henry, Rock Island, Knox, Peoria, McLean, McDonough, Adams, Logan, Champaign, Macon, Sangamon, Morgan, Macoupin, St. Clair, and Alexander Counties were not maintaining their population in 1930 on the basis of natural increase, that is, having more than 370 children under 5 per 1,000 women 15 to 44 years of age. Note that these 28 counties are located for the most part in the north third of the state, and that a relatively large city is located in each. If cities are not maintaining their population, then we must depend on the large farm families of the state and nation to keep the population growing.

Farm families, however, are decreasing in size in Illinois. If this trend continues then it will be only a matter of time until Illinois will have to depend upon outside sources for her population growth. The rate of decline can be shown in a rough way by comparing percentages in various age groups. The census gives these figures for males and females separately. The rate of decline seems more rapid for the rural than for the urban areas from 1910 to 1930. For males, the proportion in the under 5-year age group declined from 9.9 per cent in 1910 to 7.8 per cent in 1930 for the urban areas of the state, whereas the decline was from 11.2 per cent to 8.7 per cent for the rural areas. For females the proportion

[1] O. E. Baker, Future Population Prospect, *Rural Sociology*, June, 1937, Vol. 2, No. 2, page 129.

for the same age group declined from 10.2 per cent in 1910 to 7.7 per cent in 1930 for the urban areas, compared with a decline of from 11.9 per cent in 1910 to 9.2 per cent in 1930. In other words, whereas the difference for the proportion of the urban male population in the under 5-year age group was 2.1 per cent between 1910 and 1930, it was 2.5 per cent for the rural male population; and whereas it was 2.2 per cent for the urban female, it was 2.7 per cent for the rural female population (see Table I).

TABLE I—PERCENTAGES OF AGE GROUPS—ILLINOIS*

Group	Urban			Rural			
Year	1910	1920	1930	1910	1920	1930	
							Non-farm
A. Male							
Under 5	9.9	9.8	7.8	11.2	10.5	8.7	8.6
5 to 9	8.7	9.4	8.5	10.7	10.7	10.7	9.7
10 to 14	8.3	8.4	8.5	10.1	10.4	11.0	9.2
15 to 19	8.9	7.5	8.4	9.9	9.4	10.6	8.5
20 to 44	45.5	43.5	43.8	36.3	34.7	32.6	34.7
45 and over	18.3	21.1	23.1	21.7	24.2	26.3	29.4
B. Female							
Under 5	10.2	9.8	7.7	11.9	11.1	9.8	8.7
5 to 9	9.0	9.5	8.3	11.5	11.2	11.5	9.8
10 to 14	8.8	8.6	8.5	10.7	10.7	11.7	9.4
15 to 19	10.0	8.2	9.0	10.1	9.3	9.7	8.5
20 to 44	43.6	43.3	43.9	35.7	35.3	33.8	34.6
45 and over	18.3	20.6	22.6	20.1	22.4	23.3	29.0

* Source—U. S. Census.

A study of proportions in the other age groups in the population for 1910, 1920, and 1930 shows, conversely, a gradual increase in the proportions in the age group 45 years and over. Moreover, the increases in proportions in this age group were larger for the rural areas than for the urban, a change of 4.8 per cent for the urban male, 6.1 per cent for the rural male, 4.3 per cent for the urban female, and 6.0 per cent for the rural female. Part of the higher rate of increase in the proportion in the 45 years and over age group in rural areas may be due to people moving back to the country after their productive years have passed, but probably most of the increase is due to changing sizes of families.

In summary, farm families are getting smaller. If they keep on getting smaller, Illinois will soon have to depend upon immigration for her increase in population. The rate of decrease in size of families in Illinois is greater for rural than for urban areas.

Manganese as a Factor in the Fertility of Southern Illinois Soils

H. J. Snider

University of Illinois, Urbana, Illinois

Manganese is among the thirty-five elements that have been detected in the analysis of plants, according to Miller[1], and it is an element which is considered essential for at least a majority of green plants. The amount of manganese required by plants is relatively small as compared to the amounts of some of the other commonly recognized essential elements.

Generally speaking, concerning what is known of the action of manganese in soils, it may be said that small amounts are beneficial to most crops, but larger proportions may act as plant poisons and cause considerable harm to the growing plant. Manganese has a peculiarity which distinguishes it from some of the other more common elements in the soil. A deficiency is harmful to plants, an optimum amount is unquestionably beneficial, and an excess available in soils may prove harmful to some plants. The amount of available (soluble and replaceable) manganese in cultivated soils is not a constant value throughout the year or season. This may be illustrated by some determinations of available manganese in cultivated soils on the Oblong experiment field in Crawford county. On this field the amount of available manganese found in the soil about the middle of July was 400 pounds an acre and by late September the amount had dropped to 120 pounds an acre. Changes similar to this have been observed in cultivated soils throughout Illinois, and such changes are important considerations in the study of manganese and its relation to soil fertility.

TABLE I—COMPOSITION OF THE SOIL FROM LIMED AND UNLIMED PLOTS, JUNE 17, 1937

Experiment field	Soil treatment	pH	Mn, lbs.	N, lbs.	P, lbs.	K, lbs
Sparta	No lime	4.4	240	1,100	14	75
	Lime	6.3	60	1,340	32	70
Ewing	No lime	4.2	340	1,980	16	90
	Lime	6.1	50	2,120	26	75

A study of the influence of soil treatment indicates that a rise in pH of the soil causes a corresponding drop in amount of available manganese. Soils from the Sparta experiment field having a pH 4.4 had an available manganese content of 240 pounds an acre (June 17, 1937), and where the soil reaction was raised to pH 6.3 the manganese content dropped to 60 pounds an acre. Almost identical results were obtained on the Ewing field as indicated in Table I. This change in the amount of available manganese in the soil is reflected in the amount of total manganese in the young corn plants, June 17, 1937. The results given in Tables I and II indicate that the corn plant is very sensitive to the amount of available manganese in the soil.

The rise in the pH of the soil due to liming on the Sparta and Ewing fields increased decidedly the available phosphorus content of the soil, (Table I), and this also is reflected in the higher phosphorus content of the corn plants (Table II.) The total nitrogen content of the soil was increased by liming mainly due to the increased vegetative growth and the growing of legumes. The liming had a tendency to decrease the

amount of available potassium in the soil, and accordingly decreased the amount of total potassium in the corn plant. The lower potassium content of the corn plants on limed soils may be due to the increased calcium content of the plant which may represent the much discussed potassium-calcium antagonism in plants.

TABLE II—COMPOSITION OF CORN PLANTS FROM LIMED AND UNLIMED PLOTS, JUNE 17, AND THE CORN GRAIN YIELD, NOVEMBER, 1937

Experiment field	Soil treatment	Mn, %	N, %	P, %	K, %	Ca, %	Mg, %	Corn grain bushels per acre
Sparta	No lime	.220	3.40	.26	3.45	.68	.55	15.0
	Lime	.015	3.84	.42	1.92	1.18	.90	38.2
Ewing	No lime	.220	3.56	.14	2.00	.70	.53	13.4
	Lime	.022	3.54	.36	1.14	1.10	1.00	30.2

The addition of lime increased the corn yield, increased the available phosphorus in the soil and the phosphorus content of the corn plant, also increased greatly the calcium and magnesium content of the corn plant, but had the opposite effect on both manganese and potassium. These are very important factors in the fertility of southern Illinois soils.

[1] Miller, E. C. Plant physiology. McGraw-Hill Book Company, New York, pp. 232-289. 1931.

PAPERS IN ANTHROPOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Anthropology Section carried twelve papers, of which six are herewith published. The others were as follows:

Classification and Cataloguing of Indian Artifacts, by Harry L. Spooner, Illinois State Archaeological Society, Peoria.

The Newlin Mound of Southeastern Indiana, by Glenn A. Black, Indiana Historical Society, Indianapolis, Indiana.

Indian Tribes and Village Sites of Illinois, by C. L. Finfrock, Champaign County Archaeological Society, Urbana.

Plants Used by Prehistoric Man for Food and in Treatment of Disease, by John B. Ruyle, Illinois State Archaeological Society, Champaign.

Indian Relics, by W. C. McKern, Milwaukee Public Museum, Milwaukee, Wisconsin.

Banner Stones of Muscatine County, Iowa, by Ben Nussbaum, Illinois State Archaeological Society, Fairbury.

Attendance at the meeting was more than 70.

Dr. J. B. Ruyle was reelected Chairman of the Section.

(Signed) J. B. RUYLE, *Chairman*.

Lower Mississippi Traits in the Middle Phase in Illinois

Thorne Deuel

Illinois State Museum, Springfield, Illinois

Before commencing to enumerate and describe the traits referred to, it will be well to define what is meant by the term Lower Mississippi traits.

Along the Neches, Angelina and Sulphur rivers of northeastern Texas, the Sabine river of northeast Texas, and eastern Louisiana, the Red river of Arkansas and northeastern Louisiana, is found a cultural manifestation with a nucleus of traits that serve to set it apart from the Middle and Upper phases. The sites exhibiting this diagnostic series (sometimes called Caddoan) I have presumed to designate as Lower Mississippi. Among the characteristic traits are the following:

Probable Determinants, Lower Mississippi Phase

Ceremonial Complex

1. Burials in small cemeteries generally less than ten skeletons.[1] Multiple graves are rare. Dead are buried very seldom with personal ornaments.
2. Pipes are generally of pottery and variable in shape. The following types and varieties seem diagnostic, (a) the equal-armed type with projecting stem bent up and attached to bowl, (b) and the long stemmed pipe of pottery or stone with projecting stem.

Military and Hunting Complex

1. Type PP4. Diagnostic subtypes are stemmed, and pentagonal (or undulate-edged) forms. (Simple triangular present but side-notched subtype virtually absent).
2. Coarse PP1, generally a stemmed form present. (In Texas according to A. T. Jackson, seldom in graves; in Arkansas according to Harrington occasionally found with burials.)

Pottery Complex

1. (a) A coarse grayish brown utility ware, common shape the amphora or related forms decorated chiefly by brush-roughening, incising or applied clay strips (yielding designs in low relief). (b) A second type of excellent quality black, yellowish brown, or tan with polished surfaces and characteristic designs etched after firing, often with red or white pigment inlaid in the lines. Characteristic pottery forms in this second type include conical bowls, carinated bowls and a characteristic water bottle form (with shoulder low on the body). (c) A third type found is widespread but always occurs in small numbers, a ware painted entirely in red, often with etched designs and having two specialized forms, one of them a beaker resembling somewhat a conventionalized lotus blossom. Fringed or spurred lines usually in the etching technique are common decorative elements in most foci. Vertically reduplicate forms, the cockscomb head and complete animal figurine standing on the tail flange on shallow bowls, and shallow bowls decorated with knobs or nodes occur over the whole area but not in large number.

Ornaments or Insignia

1. Sheet copper forms with crude repoussé designs or ornamentation occur occasionally in Lower Mississippi sites.[2]

Middle Mississippi diagnostic traits

Ceremonial

1. The truncated pyramidal mound of earth as substructures for temples and/or public buildings.
2. The equal-armed pipe other than the projecting stemmed (Large "biconical" pottery form most commonly,) and the massive stone image pipe, stemless.

Houses

1. Rectangular floor outline.
2. Walls of wattle-and-daub type generally.

Costume and Dress

1. The employment, often in profuse amounts, of marine, cut marine shell and pearls for personal adornment.

Pottery Complex

1. (a) A dull gray type or variants with beaker, plate[3] and effigy vessel forms as well as ollas, water bottles, common shallow bowls, etc. The incised technique is probably the most common. Designs include bands and chains of hachured triangles, spirals, scrolls and arches. (b) A less decorative type but of excellent ware generally with reddish-brown to brownish gray exteriors probably used for utility and storage purposes. The chief forms are the olla and shallow bowl, common type. (c) A painted type, (possibly secured by trading) generally small in amount with two or more colors, less often in solid red. These "colors" include red, black and white and the use of the natural pottery surface at times to give a polychrome effect. The designs in color are similar to those of the dull gray type. The chief form generally is the waterbottle.[4]
2. The pottery trowel.

On account of lack of information, the corresponding traits in the two phases cannot always be compared, as for example, in the case of houses. Reports from Arkansas by M. R. Harrington indicate square (as against rectangular) and round types. The information from Texas is as scanty and less clear. The latest groups of Lower Mississippi appear to have been strongly influenced by the Middle phase, the earlier groups much less.

Some Lower Phase Traits Found in the Middle Phase in Illinois

1. The vertical-necked olla occurs in Illinois chiefly in the Tennessee-Cumberland aspect as at Kincaid and related sites. The olla is rare in some parts of the Lower phase but where it occurs in Texas along the Neches, and in part of Arkansas and Louisiana, it is of that form.
2. The seed-bowl or seed-bowl olla occurs at Cahokia in the Monks Mound aspect and to a lesser degree elsewhere as in the Spoon River Focus (Monks Mound aspect) and the Kincaid related components of the Tennessee-Cumberland. In Texas and Arkansas, it seems to have developed from the carinated or keel-based shallow bowl, and approaches rather closely similar forms of the Middle phase in Illinois and Wisconsin.[5]
3. The scalloped rim or "raised points" on the margins of vessels is common in the Tennessee-Cumberland aspect of Illinois on plates and shallow bowls; in the Lower Mississippi it is confined chiefly to the amphora (Texas) but occurs occasionally on conical and carinated bowls (Arkansas).
4. Vertically reduplicate vessels are found in Tennessee-Cumberland aspect of Illinois and in the Lower phase, in some sites in considerable numbers. (These are vessels in which a usual body form is repeated and set one upon the other, making a composite type.)
5. The short-necked water bottle (or narrow necked olla) occurs in the Tennessee-Cumberland of Illinois and is common in most aspects of the Lower phase, especially in the Sabine focus.

6. The dead are generally buried without personal ornaments in the Tennessee-Cumberland of Illinois and in the Sabine and Neches focus (lower Mississippi) of Texas.[6]

7. Burials in general seem to be individual or single, not multiple, in both Tennessee-Cumberland of Illinois and in the Lower phase foci.

8. Both type PP4 (so called "bird points") and type PP1 (Woodland) projectile points or knives are found together in the Kincaid and related components and also in the Lower phase foci.[7]

9. Large copper-faced ear disks and spools of stone and bone with designs in relief on outer surface (now in Illinois State Museum collections) were found by McAdams in a mound in Macoupin County and resemble those from the Spiro Mound and other sites belonging to or related to the Lower phase. Here also might be placed a repoussé copper turtle found in a mound in Madison County. This is similar to the repoussé work found in Lower phase sites of Arkansas. As no cultural series accompanies either of these objects it cannot be determined with what manifestations they were associated in Illinois. The stone ear spools look so much like those of Arkansas and Oklahoma that they may be aboriginal importations.

The foregoing list has been enumerated to stimulate others to check relationships toward the Arkansas-Texas-Louisiana region. It is interesting to note that the Kincaid component and several other of the Tennessee-Cumberland sites exhibit traits similar to the Eastern Arkansas aspect.

Other points we should consider are that in the first portion of the survey of the Lake Peoria region by Mr. A. M. Simpson, a member of this section, that the sites that most nearly fulfill the requirements for the Illinois Indians are Middle Mississippi, that the Illinois cabin was a long-house or rectangular house according to historic accounts, (a Mississippi and not a Woodland trait), that one tribe of the Illinois, the Michigamea came from northeastern Arkansas and that a river named the Illinois[8] rises in Benton County, Arkansas and flows into the Arkansas River to the westward in Oklahoma. Again the historic location of the Illinois not only in northeastern Arkansas but also in Southern Wisconsin, and in Illinois along the Illinois and Mississippi rivers, especially at Peoria and Cahokia coincides with the large mounds and/or village sites of the Middle phase. It would be premature however to suggest that the Illinois Indians had a Mississippi culture of the Middle phase and were responsible for the pyramidal earthworks in Wisconsin, Illinois and Northeastern Arkansas. More and careful investigation is needed to clear up this problem.

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[1] A few sites noted by Harrington and others in Arkansas contain about twenty, but only one has more than 25, viz. 43.

[2] The technique resembles rather closely the Ohio Hopewellian work of the same type rather than the more artistic Middle Mississippi forms.

[3] The plate form may be accompanied or replaced by the shallow bowl with flaring rim.

[4] The amount of the painted type increases considerably in the Eastern Arkansas aspect, and shallow bowls, effigies and even ollas as well as bottles are painted with designs or in solid colors.

[5] Harrington in fact places the carinated bowl and this type under the same designation, cazuela. The carinated bowl is lacking from practically all Middle phase sites reported.

[6] It might also be noted that Harrington, Dellinger, Moore and Pearce found the skeletons in a badly disintegrated condition, a circumstance found also in the Tennessee-Cumberland of Illinois, only traces of bone being left. Yet the cultures apparently are late, possibly in the historic period.

[7] The stemmed PP4 projectile points are found in small numbers in the Kincaid and Cahokia Components of Middle Mississippi, the last mentioned being illustrated in Moorehead's Cahokia report. This is a common type in the Neches focus and in the Spiro component of the Lower phase. Reports on finds in Southeastern sites are not clear as to the cultural relationships of the larger projectile points found.

[8] This river may have been named thus after the Illinois tribes were removed to Oklahoma but I have no information on this. There are at present too many statements and facts apparently contradicting the identity suggested above. It is, however, not without interest to note that the Illinois north of the Ohio River in historic times seem to have confined themselves to Wisconsin and Illinois, that the southernmost tribe of the Illinois lies in Arkansas and Oklahoma on the borders of the Lower Mississippi groups, with which they had in common a not inconsiderable number of traits on the level of the phase or lower units.

The Making of an Arrowhead

Charles Harris

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The base of all attainments of stone age man was the humble hammerstone, and skill in its use made possible all achievements in the fabrication of tools and weapons preceding the age of metals.

Without question, the stick accidentally splintered to a sharp point or sharpened in rude fashion by fire, and the flint fractured to an equally accidental sharp edge were first used by man without any thought of purposeful manufacture; but when one stone was used to help shape another for special uses, a great step forward was taken. First, the shattering of a flint against another would provide sharp slivers fit for use as knives. This stage of development probably lasted for thousands of years. Then came a day when a pebble was used intentionally to strike flakes from a fragment to reduce it to a better shape or to give it a better cutting edge or to restore an edge or point dulled by usage. Deftness in the use of the hammer came with practice and finally well-shaped and serviceable knives and javelin points were produced, as well as fine hand hatchets and a large variety of scraping, boring and piercing instruments. These advances in knowledge and skill had taken fifty thousand years and more to achieve. Then some tribe discovered a way of using a bone to serve as a punch to drive off flakes in such a way as to produce flint blades of greater thinness and greatly improved edge, as well as more graceful and convenient forms. All this occurred in Asia, Europe and Africa long before man appeared in the Americas. At some time, probably shortly after man appeared in America, the atlatl and the bow were used on both sides of the Pacific, and the making of the arrow head was begun.

Certain of the more ancient culture groups found in Illinois left few flints adapted for use as arrows, there being pretty strict limits in the matter of weight to which a practicable arrow point can go. In the matter of materials, while bone, horn, cane and wood were used as arrow points, it is of those of stone with which I shall deal in this paper. Here we think always of flint as the raw material, but it is true that wherever flint or its brother, chert, with the kindred types of workable stone such as jasper, chalcedony, agate and agatized wood were available, they were favorites for the purpose, except where plentiful supplies of obsidian could be used. There are large areas on the Atlantic sea board where these were not easy to obtain, and quartz, slate, shale and other less desirable stones were used. In using these last, the hammer alone was used in most cases, the quartz in many localities being found in the form of flattened, rounded pebbles in ancient sea beaches and gravel bars. A series of blows with the hammer around the edges reduced the thickness and shaped the finished product, only a single blade being obtained from each pebble. Thicker pebbles were split and a blade obtained from each half, and in the case of some of the better working pieces a more refined form may have been obtained by the use of a bone flaker.

Most of the slate and shale specimens I have examined were too much weathered to show clearly the manufacturing process but as the cleavage was simple, the flakes removed large and few and the product in most cases crude, the hammer again may have been the only tool used. It will not be necessary to say anything about the shaping of obsidian, as the cleavage and general process of manufacture were the same as in the case of flint. This brings us to the arrowheads found on the fields of the mid-Mississippi valley, but again we have a wide variety of working qualities, some of the material coming from glacial drift pebbles and boulders found along streams,

some from eroded surfaces, or mined from pits dug deep into the heavy clay residues of the limestone, some from chance exposures in limestone cliffs, and some from great veins of thick flint such as the flint ridge in Ohio. Some of this would be weathered, cross grained, checked, and as generally refractory as much of the quartz, grading up into compact smooth-grained flints which would yield ribbonlike flakes approaching the best obsidian in workable qualities.

Some campsites yield mostly crude blades made from some nearby supply of one of the poorer grades of chert, showing no work not possible with the hammer, while others show fine quality artifacts made from flint identifiable as having been brought at great expense and labor from high grade deposits hundreds of miles away; for instance, flint ridge blades from along the Illinois River, also nodular flints in large caches from Cumberland River sources.

In the more refined workmanship we find the blades carefully shaped with the hammerstone, then worked down by either pressure flaking or by use of the bone or horn punch. All this has been quite fully described in Bureau of American Ethnology, Bulletin No. 60. Although an old gentleman at Kankakee assured me some years since that in his youth he had seen thousands of arrowheads made by the Pottawatomies by heating the flint and applying a touch of moisture, I have not mentioned the method because all experiments by myself and others with whom I have compared notes have resulted in complete failure. At the time to which he referred, the Indians of Illinois had long had access to guns and steel knives and I could not but consider that he was trying to back up a theory by claiming eyewitness knowledge. On the other hand, I have seen specimens, some from local finds, but especially a fine curved knife from Egypt, that seemed almost unbelievable as works of the bone flaker; and Holmes[1] cites a number of testimonies of early writers who speak of seeing this heating-moisture method used.

My neighbor, Mr. Charles A. Benson, in leisure moments has experimented extensively with the bone flaker, and has proved conclusively that at least the majority of the flint arrowheads and knives can be made readily by a method slightly different from any I have seen described, but easily within the mechanical methods known to the Indians. He has made use of some things not known to the red man, such as a vise and a light steel hammer, but the vise is used only as a means of holding a wooden clamp, which could have been done just as readily by a stick pressed against the clamp with the foot. Perhaps the Indians used such a clamp as that made from the palm of a moose horn found and shown to me by Mr. Walter B. Smith of Brewer, Maine, and which we were only able to explain as a device for holding flint while chipping.

Mr. Benson has found that by varying the angle at which the bone is applied to the flint, and the direction and force of the blow, he can strike off flakes either abruptly to produce a typical bevel or to draw the flake well across the face of the blade. By far the easiest point to make is the small point made from a thin flake, of the type used in large numbers by the Middle Mississippi culture, but the production of the flake from which to shape them requires a very skillful workman and a good grade of flint from which to produce them. The common Woodland type of arrow point, on the other hand, requires more flaking but can be made from a much ruder flake as a starter. Mr. Benson has never had access to a really satisfactory flint, mostly using the glacial deposit for his source of supply, and does not know whether he would be able to strike off long flakes from which to make the larger spears and knives if he had the quality needed, but specimens of his workmanship will, I think, clearly demonstrate that should necessity require, very satisfactory arrowheads could be produced by the percussion method which he used in his experiments.

In his work he uses the bone, well dried and free of grease, largely as a buffer to transmit percussion, having failed to get satisfactory results from pressure alone. The clamp is faced with a bit of leather to prevent too uneven local pressure breaking the piece being worked, and to provide a certain amount of cushioning to permit flakes to extend down within the

clamp. Seating the bone firmly at the angle experience has proved desirable, a light tap with the hammer removes a flake, which practice has enabled him to control quite exactly. Usually the blow is applied to the side of the punch, rather than to the end. Reversing the work frequently, first to attain a working edge, then carefully trimming for symmetry, in a short time he will have produced an arrowhead in many cases better than any but the best made by the red man.

The experiments were purely a matter of obtaining knowledge, and Mr. Benson has never used his skill in producing any of the reworked "rare forms" nor ever parted with any arrowhead except as a gift to a friend.

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[1] Holmes, W. H., Bureau Amer. Ethnology, Bull. 60.

Evidences of Early Woodland Culture at Chalk Bluff Rock Shelter[1]

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Rock shelters and caves are ubiquitous features in the Shawnee Hills or Little Ozarks. The Shawnee Hills occupy parts of the three southernmost tiers of counties in Illinois and are located in the crotch of the Y formed by the junction of the Ohio and Mississippi rivers. Here, the terrain is of a hilly nature, generally rough and broken with many precipitous rocky slopes, and has a maximum difference in elevation of approximately 600 feet. At the base of many of the perpendicular cliffs (a conspicuous feature of this area) are found rock shelters. These shelters are formed by a more rapid weathering of the exposed basal rock material than of that higher on the bluff so that we have an overhanging cliff. There is material evidence that these rock shelters have given cover to prehistoric man, the historic Indians, early white travelers and settlers, as well as livestock and machinery of the present day dwellers.

These overhanging cliffs furnish such fine protection from the weather elements that it would seem only natural for early man to take advantage of their existence. Just how early and how long and by whom the shelters were occupied can be determined only by careful investigation of their sites.

The site of Chalk Bluff rock shelter is the southern end of Chalk Bluff in sec. 2, T. 10 S., R. 3 W., approximately nine miles southwest of Murphysboro in Jackson County. The Chalk Bluff in which this shelter is located is an unbroken sedimentary rock escarpment nearly one mile long and has an almost uniform height of 250 feet. Calcareous sandstones are the predominant rocks in the cliff-like escarpment. This escarpment, lying in a north-south direction and paralleling the Mississippi flood plain has a westerly exposure. Here, where the shelter is located, is a conspicuous overhanging cliff offering the shelter ideal protection from the weather elements. Huge boulders having fallen from the cliff furnish ground protection from westerly winds. Some of these boulders are over 6 feet high. The shelter itself is about 60 feet long and about 40 feet wide.

At the time of excavation, the filled-in floor was from 4 to 6 feet deep and contained a large number of fallen slabs and boulders. These were found lying in such a position that it seemed necessary to begin excavating from the back of the shelter and work outward. Just how long these boulders, varying in weight from a few hundred pounds to several tons, had been buried can only be conjectured. However, they were buried so deeply in the floor debris that they could not have fallen into the debris to such a depth. Therefore, the debris in part at least had been filled in around them.

Judging by the fire-smoked walls, and a few flint spawls, potsherds and fragmentary bones found scattered about the floor, the writers felt the find to be of importance and were certain that further excavation would reveal more interesting remains.

As work progressed, it became apparent from the charcoal beds, crematory pits, ashes, fragmentary animal bones and human bones, especially those of children, found in the floor debris, that man was an early and prolonged occupant of this shelter.

Work was started at the back of the shelter by digging a trench five and one-half feet deep, parallel to the bluff and down to the original stone floor.[2] In the process of digging, an abundance of prehistoric evidence was found. This evidence was in the form of flint chips, bone awls, potsherds, and fragments of bone found throughout the floor debris. All the floor debris was

taken from the trench and passed through a one-half inch screen in order to secure all fragmentary bones, potsherds, flint and bone awls. Because of the dry powdery condition of the debris and the large rocks that could not be removed, much difficulty was encountered by cave-ins.

No burials were found until the trench reached the rock floor of the shelter. The first skeleton was found lying in a semi-flexed position and badly crushed by fallen rock. After the trench was widened to about 10 feet, several parts of burials were found in close proximity. These burials were found tightly wedged between and under fallen slabs, and were apparently badly crushed by the weight of heavy rocks.

The finding of these burials created much interest. The fragmentary skulls showed a decided flattening of the frontal bone; another peculiarity evident was the shape of the skull indicating prognathism and pathological conditions. This skeletal material was covered by a thin layer of whitish substance that could not be identified. This same material was also found on the stone floor at the bottom of the trench and was covered by about four and a half feet of filled-in floor debris.

At this stage in the excavation, work was stopped. Believing the find to be one of unusual importance, the writers sought the aid of professional archaeologists. Since it seemed impossible to get someone interested enough to take over the work, some of the material was sent to the Milwaukee Public Museum, Milwaukee, Wisconsin, for study purposes. In the meantime, continuing with the excavation, it was decided to widen the trench. A slab weighing approximately a ton was encountered lying on top of the dirt floor. By working carefully we were able to dig under this rock. Excavation here revealed the cremated body of a young child, and in juxtaposition was found a large piece of red ochre and a burnt snail shell bead. This was the only instance where grave goods were found with any human skeletal material. Near this cremated body were other evidences of cremated burials, but the large slab prevented further explorations. After digging a few holes on both sides of the slab to see if anything of importance could be found in the dirt, we abandoned work here.

From the animal bones that could be identified, the Virginia deer was found to be the most common; also present were those of the elk, wolf, fox, beaver, woodchuck, squirrel, raccoon, oppossum, and wild cat.[2] Practically all of the bones had been broken. This probably was done to extract the marrow. Shell remains from several varieties of fresh water mollusks and snails were found along with fragments of terrapin and turtle shell. Remains of fish and bird bones were also present. The remains of the animals mentioned here were the most numerous of all materials recovered. Such a large quantity of animal bone suggests a long and continued occupancy of this shelter by prehistoric man who used it either as a permanent abode or as an oft frequented shelter during hunting expeditions.

A very few projectile points were found, and a very small amount of flint spawls and chips. The points are crudely made and are of the stemmed and notched base types. They are all less than two inches long and suggest a very limited knowledge of flint chipping. The flint projectile points recovered were made from the "flint ball" and "novaculite" cherts. The material for these points came from the prehistoric quarries found in Union County, about ten miles southeast of Chalk Bluff.

The bone awls and ornaments of bone and shell that were found are very interesting. The bone awls, made from deer and bird bones, are highly polished and some of them are six inches long. The ornaments are of two types, bone and shell. The former are parts of bird bones made into beads, while the latter are made of fresh water mollusks perforated for suspension. One of the numerous wolf tusks found was perforated.

The potsherds found in this shelter seem to be typical of the Woodland culture. They are all tempered with a coarse grit and have a granular texture. The shoulders are poorly defined while the necks are straight or slightly curving. The bottom fragments include several with flat bottoms; the rest have rounded bottoms. The flat bottom ones are very crude and compact. In contrast with the potsherds found in other bluff shelter sites in southern Illinois, those found in the Chalk Bluff rock shelter have very

little decoration on the rims. A few specimens, however, show incised zigzag lines, raised points and small imperforations near the rim. Most of these have been poorly fired in the process of making. They varied in thickness from one eighth to almost five eighths of an inch.

One of the writers, having studied other rock shelters in southern Illinois, believes there has always been a marked resemblance in the potsherds, bone tools, and other remains found in the various shelters. In these rock shelters, evidences of agriculture such as small digging tools and charred corn cobs[4] were found. In none of them was there any evidence of the use of tobacco, such as would be indicated by the presence of pipe or pipe remnants.

The Chalk Bluff shelter differs from other shelters in that no evidence was uncovered that might lead one to believe that these people knew anything about agriculture. The only textile evidence found was the cord imprint on pottery sherds. Judging by the remains found in the shelter, it seems that the inhabitants were unskilled in working flint, and possibly did not know about the use of the bow and arrow.

Up to the present time rock shelters in southern Illinois have been neglected in scientific research, while the more conspicuous mounds of the State have been and are being thoroughly studied. In conclusion, the writers wish to say that they and others are of the opinion that a thorough investigation of these rock shelters should be made—preferably by or under the direction of well-trained archaeologists.[5] Investigations of these shelters may reveal important information on man's early occupance of the State. However scientific study should not be too long delayed. Since the partial excavation of the Chalk Bluff rock shelter, upon which this paper is based, was stopped, "pot hunters" have blasted the boulders in the shelter several times. Frequent vandalism is destroying important scientific archaeological material in the rock shelters of southern Illinois.

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[1] Knowing for some time the existence of this shelter a group of interested persons went to this shelter on November 14, 1937, and spent several days excavating. The party consisted of Charles Thomas, Joe Thomas, Warren Whelpley, all of Cobden, and Homer Benz, Raymond Benz, and Irvin Peithman, all of Carbondale, Ill.

[2] This method of excavation is no longer used. In the last excavation in which the writers worked the five foot square method with horizontal layers removal of material was employed.

[3] These animal bones were checked by Dr. L. A. Adams of the University of Illinois during December, 1937.

[4] Peithman, Irvin: "Bluff Shelters on Indian Creek, Jackson Co., Illinois," *National Archaeological News*, Vol. 1, No. 11, pp. 6-9, 1938.

[5] Since this paper was written, a partial excavation of the Cave Hollow rock shelter in Jackson County has been made under the guidance of Professor Fay-Cooper Cole of the University of Chicago and his men, Dr. Horace Miner, Wayne University, Detroit, Michigan and Mr. L. Robert Tschirky, Philadelphia Museum.

Bluff Shelters of Union County

C. Joe Thomas

Cobden, Illinois

In the conglomerate and underlying sandstones of Union county, Illinois, are numerous perpendicular bluffs of varying heights. The several forces of erosion have produced indentations in these bluffs, commonly in their bases. Many of these indentations are so formed and situated that they are natural shelters. In some cases, water runs over their floors, while in others their interiors have been perfectly dry for great periods of time.

In practically all of these shelters some bits of evidence of prehistoric human occupancy can be found on the surface. Over the past fifty years or so, the surfaces of the dry cave floors have been scratched by collectors in search of Indian relics. Three or four years ago, the writer and his brother became interested in these places as anthropological sites.

These grottos existed, no doubt, in a condition very near their present one, when the first human entered them. Why then, is there not a possibility of finding, somewhere in the debris of their floors, some evidence of the earliest as well as the latest human occupant?

With this in mind, the writer and his brother excavated a shelter, four miles north of Cobden, in 1935. It is 57 feet long by 25 feet deep at its greatest depth. It was found that the dust and sand was accumulated therein, to a maximum depth of 5½ feet. This entire dust layer was removed and passed through a ½-inch mesh screen, and was found to be heavily impregnated with flint chips, bones, shells and potsherds. Flint chips were most abundant near the surface and decreased as the bottom was approached.

Among the artifacts encountered were seventeen war points; several of these had delicately serrated edges, the others were of the plain triangular type. There were about fifty complete and numerous fragmentary arrow heads. They were mainly of the stemmed variety, a few were notched, and all were very crude. Six complete bone awls and four fragmentary ones represented the work in bone. There were a half dozen mortars, made of unshaped creek rocks. One mortar weighed several hundred pounds and contained an unusually deep basin. A number of tips of deer antlers were found; these had been cut from the horn by man, and three had holes bored in their bases. There were three beads or ornaments. One was a delicate arrow head with a notched base and serrated edges; it was slightly over an inch in length, and made of mussel shell; the other was an imitation animal tooth made of stone. Both were drilled for stringing. There was, also, an antler tip, highly polished, with a notch cut around its tip, and one half of a crude gorget. No agricultural artifacts were found in any condition.

The potsherds represented both shell and grit tempered pottery. They were generally roughened on the outside by a sharp instrument or a corded stick. Many of them were burned on the inside and not on the outside. Rims were mostly straight, sometimes slightly flaring. Few attempts at decoration were in evidence.

The above material is more or less typical of that found in other shelters of this locality and the neighboring ones, judging from cursory examinations and the reports of others.

One remarkable feature of this shelter was the fact that fragmentary human bones were interspersed throughout the mass of animal and bird bones in the same condition. There were fragments of lower jaws, upper jaws, with teeth worn to the bone, skull fragments, toe and finger bones, knee caps, shoulder blades, and fragments of the pelvic bones and arm and

leg bones. At a depth of 5½ feet, a test hole in the hard clay beneath the dust revealed fragments of a human skull and a lower mandible. There was absolutely nothing more in association with them. The skull fragment had a very heavy brow ridge. Other brow fragments, found at higher levels, showed no brow ridges and were structurally delicate in comparison. They were, also, white in color, while the lowest jaw and brow fragments were a deep brown. There was no indication of these bones ever having been burials. In only one instance were bones found grouped together; at a depth of two feet, against the wall of the shelter, a few vertebrae and two femurs were found together. From the fact that the bones showed no signs of decomposition, it would appear that the bones were deposited there in their present condition. It was, indeed, a conglomeration hard to account for, and was suggestive of cannibalism.

Practically nothing concerning cultures among these bluff dwellers has been defined; and it appeared to the excavators that this shelter contained the remains of more than one cultural division of prehistoric man. What was suspected here might be confirmed in others.

In a bluff 3 miles east of Cobden there is a series of large shelters. Ancient and recent rockfalls cover their floors, until excavation is impossible without the removal of tons of rock. Test holes between these rocks reveal a profusion of remains of ancient occupation. One test pit dug to a depth of 5 feet exhibited no bottom of the dust strata, nor any decrease in remains. Across a spur of one of these bluffs is built a so-called stone fort. There is known to be, in southern Illinois, 8 of these rock walls built in prehistoric times. It has been noted that habitable shelters are near each of these structures. Their builders might have been bluff dwellers.

No doubt, judging from the similarity of remains found in various bluff shelters, one cultural division of ancient man occupied them more than any other kind; yet, considering the length of time they have been available for habitation, the writer believes it is possible to find, within them, some information concerning prehistoric man in this locality, from his beginning to and including the last nomadic bands of the American Indian.

Religious Beliefs of Prehistoric Man of North America

Harry B. Wheaton

Clinton, Illinois

No race of people as far as we know has ever existed but had some form of worship or some God or gods to whom they bowed in reverence. In spite of the fact that recent writers have attempted to prove that the American Indian was atheistic in tendency, their legends and traditions prove otherwise. Through these, we find that their beliefs followed the same general line of all other religious creeds. In a way all religious creeds follow the same general scheme. They account for the origin of the earth, the sea, the celestial bodies, the animal and plant life, and finally for the presence of man, all of which is controlled by some mighty personage who lives in the great beyond. Laws have been set up regulated by the divine will, the keeping of which insures the individual of living to a ripe, peaceful old age and when the mortal body ceases to function, he is transported into another world to live for eternity.

In view of the fact that over one hundred tribes lived in North America before the coming of the White Man, that each of these tribes varied slightly or extremely in belief and ceremonies, it is impossible to give more than a brief review of their beliefs in regard to the creation, their ceremonies to propitiate their Gods and their views of immortality.

The handbook of the American Indian recognizes five large subdivisions:

1. the Eskimo area in which the preponderance of opinion holds man in the Hero role. Very little tradition is devoted to the animal but when so he is linked to man.
2. the North Pacific Coast area, where there has been built a large cycle of transformed myths, relating to that region, the origin of arts, the whole of which is loosely knit together in a disconnected mass of folklore.
3. the Western Plateau and the Mackenzie Basin, where emphasis is laid on tables of animal in which they are linked to present day conditions. They are not closely connected and are contradictory in character.
4. the California Area, the mythologies of which are grouped around the theme of creation by will power.
5. the region of the Great Plains, the Eastern Woodlands and the Arid Southwest in which the myths are systematized in the form of a well developed ritual.

Early man of North America was a dweller of the forests, rivers, mountains and hills and so his God or Gods were those of nature. He was a creature of his environment. Caves, mountains, curious rocks, waterfalls and in fact any object that excited his curiosity (especially among those of the Great Lakes Region) was supposed by them to be the dwelling place of a Spirit. These imaginary deities became the object of dread or veneration. To these an offering of tobacco was given, not as an atonement for sin, but to obtain temporal advantage or to avert the anger of the spirits.[1] From this same source we have recorded that the sun, moon and stars were also adored. Usually the natives of this region believed in the existence of one great Spirit, with innumerable subordinate deities who have particular control over their destinies. They believe in the existence of evil spirits and made offerings to appease their anger.

The Zunia of the West worshipped a God who was the Maker and Container of All, who created the primal fogs and mists and took upon himself the form of the Sun with all its personal attributes, then by his own bright-

ness and light he thickened the primal mists into water thus creating the sea. Out of his own flesh he fecundated the Sea. Out of the Sea came Mother Earth.

Some of the Iroquois have a unique legend explaining the lesser brilliancy of the Moon by stating that in the long ago the Moon Mother married the Sun. She was unable to stand his extreme temperature so she fled and hid in a cave. Fearing his wrath, she remained hidden so long that she pined away until she nearly died. She never recovered her original brightness. When she fattens up she remembers her husband's wrath and pines away again.

The American Indian had a superstitious fear of the animals, who, they thought, influenced their lives for good or evil. The Algonquin and other tribes believed that the animals fearing extinction called a council to decide ways and means of combating man. The deer agreed to visit man with rheumatism, the insects to inject malaria poison into his system, the reptiles to cause him bad dreams and the birds to give him lung trouble. In order that he might be successful in the chase and ward off misfortune, he always carried in his medicine bag a rabbit's foot and other parts of animals to protect him from the enmity of the animals. Those superstitious white people who today carry a rabbit's foot, would hardly believe that the belief came down from the primitive Indian who long ago reverently placed it in his medicine bag with the hope that the Gods of Chance would protect him and see that he was well rewarded. In order to propitiate their Gods, it was the custom of some tribes to address a bear as "brother" before he was slain, and carefully explain to him that it was very necessary, otherwise his soul might return and have a baneful influence on them. The Chippewa Indians always addressed the tobacco plant before harvesting it: "You are allowed to grow here for the benefit of man and I give you this tobacco to remind you of this, so that you will do the best you can for me." Then he would deposit a little dried tobacco where the plant grew. The Chipmunk was considered to be an omen of good fortune for it was he alone of all the animal kingdom, who after the Indian had been visited with the different plagues by the Animal Council, had gone to the plants and trees and persuaded them to part with their medicinal properties to cure their ills and relieve their sufferings.

Primitive man must have believed in the immortality of his soul, for in no other way can we account for the great amount of labor expended in building the many mounds that dot the region of the Mississippi Valley; most of which were built to cover their dead who, when they reached the Happy Hunting Ground, would be adorned in a manner befitting their position and would have all the necessary implements of the chase.

[1] West's "Tobacco, Pipes and Customs of the American Indians."

Hopewell Traits in Certain Bluff Mounds of Fulton County

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The site described in this paper is composed of a group of 18 mounds, a cemetery, and at least one village, which are strung along the north bluff of the Illinois River for a quarter of a mile in the southeast corner of Fulton County. In a wooded tract behind the mound are 5 house pits which have never been disturbed by cultivation or by excavators. The village and cemetery have yielded interesting material of the Middle Mississippi culture and will be dealt with in a later paper. In this report I shall give the results of our investigations of the mound group.

All of the 18 mounds are low and circular, the smallest being 11 feet in diameter and 15 inches high, while the largest is 63 feet across and 7 feet high. Most of them are arranged in a single line paralleling the edge of the bluff for a distance of a thousand feet. Four are irregularly placed outside of the general line. They are composed of light yellow clay which forms the sub-soil in this region. All of the prominent mounds have had pits dug into their centers many years ago, but there is no record as to what was found. Trenches dug into several of them yielded no evidence of burials or of any artifacts.

The three mounds at the east end of the group are a few hundred feet removed from the next in the line and are low and inconspicuous. For these reasons they escaped the notice of the persons who opened the other members of the group. The first mound which we opened was the third mound from the east end of the group. It was roughly thirty-four feet in diameter and in most places the artificial deposit was only eighteen inches thick, although the curve of the hilltop added to the apparent height of the mound.

The first burial which we encountered was flexed on the left side and lay on the base of the mound 18 inches below the surface. A few feet away on the same level were the disturbed bones of a child. Beside this burial were fragments of grit tempered pottery. When reconstructed they formed a globular pot with a slightly constricted neck and a plain almost vertical rim. The body of the vessel was roughened with narrow parallel incised lines drawn vertically from the rims. Two other fragments of grit tempered pottery were found apart from any burial.

A little to the south of the exact center of the mound lay a confused mass of bones which represented at least three individuals. The bones were only 16 inches below the surface and may have been disturbed by the pick of some previous digger. However we feel that the bones were undisturbed and represent a bundle type burial. In this group of bones was what appears to be a trophy skull. It consists of the occipital and parietal bones with the edges left rough. It exhibits two scars and a depressed area which might have been caused by a severe blow.

Directly below the bundle burial was a pit which was roughly eight feet square and extended 2½ feet below the base line of the mound. This pit contained the remains of twenty individuals, of which seven were represented by the skulls only. The complete burials were all extended face up with the exception of one partly disturbed body which lay face down. In this case the skull exhibits a number of long scratches across the back.

Three adult burials were laid one above the other, and on the chest of the lowest burial lay five skulls. Seven of the burials were of children and infants. The only artifact recovered from the pit was a pearl bead which was found with a child.

The next mound which we opened was second from the east end of the group. This was 28 feet long and 23 feet wide, with an average height of 15 inches. In the center of the mound was a circular area 12 feet in diameter which was covered with small flat pieces of limestone. Beneath the stones were the skeletons of two infants and traces of an adult. With the adult burial was an elaborate grave offering consisting of the following objects: A mica reflector 7 inches across and roughly circular; a 3 inch square based obsidian knife or spear head; a beaver tooth and a necklace of 51 rolled copper beads. Pendant from this were two bear teeth which were grooved at the end for suspension. Between the bear teeth was the leg bone of a dog, five inches long which had been polished and cut at one end. Although it is neither grooved nor drilled, its position indicated that it might have been hung between the two teeth. Part of the original necklace cord was preserved inside the copper beads. It was made of two threads twisted together. Each of these threads was composed of a number of coarse hairs.

The traits displayed in these two mounds do not fit into the middle Mississippi culture of the adjacent village. They do however correspond to the Hopewell pattern as it is defined by Cole and Deuel.[1] The central subfloor pit containing extended burials, the use of pearl beads, grit tempered pottery, copper beads, bear teeth pendants, mica sheets and obsidian, point unmistakably to the Hopewell culture. Most of these traits have been reported from other sites in Fulton County, but as far as we know this is the first discovery of obsidian. Another unusual feature in the second mound was the covering or pavement of small stone slabs over the central burials. Construction of a series of small mounds along the bluff is contrary to usual Hopewell practice, which was to build rather large mounds in the bottom lands.

Possibly the variation here was forced by the narrowness of the strip of land bordering the lake at the foot of the bluff. Local informants say that village material was found during construction of a road along the base of the hill, and this may possibly be the site of the Hopewell village which is otherwise unknown.

[1] Cole, F. C., and Deuel, Thorne, "Rediscovering Illinois."

PAPERS IN BOTANY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Botany Section carried nineteen papers, of which thirteen are herewith printed. The others were:

The Structure and Development of the Radish, by E. L. Stover, Eastern Illinois State Teachers College, Charleston.

Exploring for Fossil Plants in the Tropics, by A. C. Noé, University of Chicago, Chicago. (Lantern slides.)

Luminous Moss, A Demonstration, by Blanche McAvoy, Illinois State Normal University, Normal.

Preliminary Report on the Developing Biota of Southern Illinois Strip Lands, by W. M. Gersbacher and Wm. M. Bailey, Southern Illinois State Normal University, Carbondale.

Some Suggestions for the Effective Use of Freehand Sections of Plant Tissues in Laboratory Classes, by Helen M. Thomas, Rockford College, Rockford.

Demonstrating the Relative Humidity of the Intercellular Spaces of Leaves, by H. F. Thut, Eastern Illinois State Teachers College, Charleston.

Average attendance at the meeting was 40.

Dr. E. M. R. Lamkey, Illinois State Normal University, Normal, Illinois, was elected Chairman for the 1939 meeting.

(Signed) P. K. HOUDEK, *Chairman*.

Ecological Aspects of Host Specialization in Fungi

L. R. Tehon

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The role of fungi as parasites of higher plants has been recognized now for just about 100 years. And the significance of fungi as destructive agents, recognized centuries before their exact nature was understood, has led within the last fifty years to such advances in knowledge concerning them as can be duplicated in few, if any, of the other branches of natural science.

Because they are minute, obscure, and often secretive in their activities until they have done so much damage that human efforts against them are futile, the greatly merited investigations and researches aimed at finding means for combating them naturally have fallen into three chief categories: first, development of poisons which can be applied as preventives; second, life history studies, chiefly of a laboratory nature, aimed at an explanation of the obscurities of their existence; and third, discovery or breeding of races of plants resistant to their attack.

Control measures now in wide use are based largely, though it is true not entirely, upon knowledge gained in these three fields. Poisons, in the form of sprays, dusts, and washes, are used extensively as applications often intended for one parasite but as often acting more or less efficiently as blanket preventives of anything and everything that may happen along. Interruption of the normal progressions of life histories is the basis for barberry eradication in controlling stem rust on small grains, for *Ribes* eradication in controlling white pine blister rust, and for local eradication of red cedars in controlling cedar rust of apples. In recent years, agriculturalists have favored greatly the development of resistant varieties; and if the varieties secured have not always been as satisfactorily resistant as might be desired, certainly much has been learned about plant breeding, *per se*, and many varieties of crops have been obtained that are valuable in other ways.

More direct in approach, if less favored in research and in use, is physiological control, exemplified at one extreme by the hot water method of seed treatment, which differentiates so closely between the temperature resisting abilities of parasite and host, and at the other by the planting of crops in relation to soil temperature, which stresses differences between host and parasite in ability to grow.

Nearly ignored in research, and entirely so in practice as a means of control, though by no means omitted from extensive speculation as an influence in the development of wide-spread and destructive epiphytotics, have been the ecological relationships of parasite fungi. And plant disease specialists are by no means alone in neglecting this broad field. Plant ecologists have, to the present, dismissed fungi with few words and correspondingly little thought. Unfortunate it is, perhaps, that in science, as in society, size and conspicuous domination attract interest and command thought and effort to the exclusion of obscure, behind-the-scenes and, perhaps therefore, more influential relationships.

The sole point in all the foregoing is to bring out, with the emphasis incident to enumeration, that there is extant now in the science of plant pathology an accepted set of beliefs, on which present day practice is largely based, that is adhered to with much the same literality that the St. James version is accepted by many religious believers. And it is the purpose of the remainder of this paper to suggest, on the basis of a number of cir-

cumstances falling directly within my knowledge in the State of Illinois, that it is high time to examine with considerable care our original text, with a view toward modernization of our tenets in plant disease control as well as with the intention of stimulating new research and, what may be much more important, new and original thought.

One can have no objection to the present use of poisons. This is entirely a commercial matter, in which the collaborating interests of poison manufacturer and crop producer can be depended upon to increase effectiveness and reduce cost to the highest and lowest degrees possible. Neither is there much cause to discourage those who believe in the efficacy of plant breeding. It is, undoubtedly, a field without limit, exceedingly complex in its aspects, interrelationships, and consequences and worthy of most extended attention.

It is life histories, and particularly the thinking that is based on what we know about them, that I want to bring into question, today.

The first suspicion that dependence on current knowledge of life histories might be not entirely safe as a foundation for control measures came with the publication in 1927 of Craigie's[3] simple and conclusive experiments, which demonstrated the function of the pycnospores of the rusts.

For nearly a quarter of a century, in fact following the cytological researches of Sappin-Trouffy[2] in 1896 and of Blackman[1] in 1904, it had been supposed that the phenomenon of combination and resegregation of characters attendant on cross-fertilization had been reduced among rust fungi to a vestigial and only partially completed process accomplished entirely within the thallus unit. Craigie's effective experiments proved that cross-fertilization was by no means the vestigial process it had been supposed to be but was, instead, an absolutely necessary function accomplished upon the aecial or "cluster-cup" hosts, without which the life histories of many types of rust fungi could not be completed, and that instead of being accomplished in a vague sort of way within a single thallus it was accomplished in the regular manner by the crossing over of fertilizing cells from one thallus to another. The inescapable conclusion had therefore to be that the rust fungus organism, as to species, was not an agglomeration of specialized and stabilized races, but, instead, that the species were composed of constantly changing races and that the origin of new races with new characteristics, especially of parasitism, might take place whenever the fungus was inhabiting its so-called alternate host.

The bearing of this discovery of Craigie's upon control measures in practice and under development was naturally two-fold. In the first place certain control measures, such as Barberry eradication, were based on the assumption that if the alternate host could be eradicated or nearly eradicated it would be impossible for the parasites to develop in quantities injurious to the economically valuable host. In the second place, with parasite races genetically stabilized in parasitic ability and invariable, as required by the life history of the parasite, it would be possible to develop races among the economic hosts which would be resistant to all of the parasitically differentiated races of parasites. The effects of Craigie's experiments were, first, to suggest the possibility that, with reduction in number of alternate hosts, some few of the continually changing forms brought about by recombination and segregation of characteristics among the parasites might possibly be adapted to survive without dependence on the alternate host and, second, that with continually changing characteristics in parasitism it would be impossible for geneticists to develop a sufficiently large number of resistant crop races or varieties, or any one race with resistance complete enough to assure escape under all circumstances from the ravages of the parasites to which they were supposed to be resistant.

The latter consequence is, of course, a matter for the consideration of a specialist in plant breeding. It presents questions that can be answered only after many years of experiment and it may in the end make the plant breeder's problem both the more difficult and the more interesting because of its increased complications. The real problem from the point of view

purely of plant disease control lies in the first consequence. And of course we should ask, first of all, whether there is at hand any experience or knowledge which bears directly or indirectly upon it.

Within the State of Illinois we have every year experience with, among many, two diseases which it seems to me bear definitely on the problem. One of these is the well-known leaf rust, *Puccinia triticina*, of wheat. The other is the prevalent but not so destructive rust of corn, *Puccinia Sorghi*. Both of these rust fungi are known to have alternate hosts. That of the common and destructive leaf rust of wheat is a species of Meadow Rue (Thalictrum). The alternate host of corn rust is a species of the genus Oxalis, which includes the common sheep sorrel of gardens, *Oxalis stricta*. In spite, however, of the fact that the alternate hosts of both of these parasitic fungi are known, as a matter strictly of scientific information, to function in the life history of the parasites under at least experimental conditions, it remains an uncontrovertable fact that both organisms persist from year to year in some manner, so as to reattack each growing season, sometimes with disastrous results, the crops upon which they have become specialized, and do so independently of their alternate hosts.

These two examples have the disadvantage in the first place of being exceedingly well known, and in the second of being selected with respect to attacked hosts which are grown abundantly over exceedingly wide geographic ranges, so that variations in climate may readily account, if the proper type of reasoning is used, for the persistence of the parasites in milder-climated portions of the host range during those seasons when survival in the severer climates would seem impossible.

It is, therefore, desirable to search out other examples with a stricter and less critical bearing upon the question of alternate host and life history control. In the State of Illinois two of these are now available.

The first, it seems to me, is outstanding in particular respects. There is a rust, known technically as *Pucciniastrum americanum*, which has for its two hosts a spruce, *Picea canadensis*, and a bramble, *Rubus strigosus*. The natural range of both hosts lies much to the north of Illinois, and the range of the fungus on the first host is only known to include the Canadian province of Ontario, while the range on the second host has been reported to include territory as far south as Connecticut, Ohio, and Iowa. The striking circumstance in Illinois is this. The Latham raspberry, which is a very popular, cultivated red raspberry derived from the native host, *Rubus strigosus*, has been planted commercially in the extreme southern tip of the State, from Carbondale southward, and particularly on that east and west highland known as Villa Ridge. There is not any native alternate host, the spruce species, within many miles of these raspberry plantings. Yet unfailingly the rust makes its appearance upon the raspberries late in the season in the Villa Ridge region and as far north as the hills to the south of Carbondale. Here apparently is a case of a rust requiring two hosts for the completion of its life history, which has followed, in one phase only of its life history, the particular host upon which that life history is passed a very considerable distance, perhaps as much as 500 miles, south of its normal range, where it appears to propagate itself year after year in connection with its particular host and utterly without regard for the absence of the other host.

The second instance has to do with white pine blister rust. This destructive pine disease, caused by a fungus known as *Cronartium ribicolum*, has been known for a considerable number of years in New England and northeastward. More recently it has occurred in northwestern states. Within the last two years the white pine blister rust fungus has been found in Illinois on one of its hosts, *Ribes nigrum*. Infections have been definitely reported in Lake, Boone, Kane, and Winnebago counties. The natural range of the other host, white pine, in Illinois does not include any of these counties, and if white pine does occur in these counties it is only as an occasional decorative planting. It is important to note that up to the present time no case of infection of white pine blister rust has been observed in the State on white pine, either in the counties where infection has been found on the alternate host or in regions where white pine is native.

A point that seems full of significance in all of these cases, including the important rusts of cereals, is that the disease-producing fungus is able, by some means we do not now understand, to propagate itself through as wide a range as that occupied by its host and does so quite independently of the presence or absence of its alternate host. It is significant, also, that this propagation occurs in connection with a very definite phase of the fungus life cycle. This phase is usually, though not always, the one that attacks the economically important host. The significant thing about it, however, is not that it attacks the economic host but that it is the phase of the fungus which has a very definite means of abundant propagation by means of vegetative spores. In the case of the stem and leaf rusts of wheat and the rust of corn, there is a period known as the "red rust" stage, where propagation from one host individual to another takes place rapidly and freely. This likewise is true of the rust on the Latham raspberry and of the white pine blister rust on Ribes.

This fact may be considered to account for widespread infection of the host on which the fungus is found, but it does not account for the manner in which original infections of the host occur. We are unwilling to admit, what has often been maintained, that early spring infections must take place by means of spores produced on the alternate host.

It seems to me that there is room at this point for very serious thoughtfulness with regard to permanent interrelations between host and fungus. The suggestion that may be drawn from our examples is this, that any fungus parasitic upon plants, which has in any given part of its life history a definite vegetative reproductive phase, possesses a degree of adaptability that makes it possible for the fungus to exist and multiply in any region favorable to its host.

And if such an assumption as this can be tenable, a logical step is to admit that parasite and host constitute together a definite interrelationship, whereby in any environment, whether under cultivation or in nature, the multiplication of the host is restricted by the activities of the parasite and the multiplication of the parasite is conditioned by both the presence and the abundance of the host.

In the development of epidemics of plant disease, especially as they affect hosts or crops of economic value, a great deal of importance has been attributed to weather. This perhaps is the natural outlook from the standpoint of economics, since crop acreages, although varying in total from year to year, always remain so large that an abundance of hosts is always present and furnishes opportunity for large increase in parasite numbers through the growing season. But from the standpoint of the ecologist, who deals with the world's natural inhabitants, undisturbed by man's economic needs, it is perhaps more important to consider the relative effects of alternate increase in host abundance and increase in parasite abundance, followed by decrease in host abundance and more than proportional decrease in parasite abundance.

This in a sense may be looked upon as paralleling certain well-known zoological examples, where the rise and fall of large populations of rodents in the northern part of our continent is attributed to a similar but delayed rise and fall of predators, and possibly in some cases also of internal parasites.

From the ecologists point of view, it is also worthwhile to examine certain relationships of fungi which cannot definitely be said to be parasitic, and in this connection I should like to bring forward certain experiences that have occurred in our own laboratory.

During the past several years, we have been examining as a routine matter considerable numbers of chinch bugs, particularly for the purpose of determining the relative prevalence of the so-called chinch bug fungus, *Sporotrichum globuliferum*. These tests were begun in the late winter and early spring of 1935, following the exceptionally destructive outbreak of chinch bugs in the summer of 1934. That spring the chinch bug fungus was isolated without fail in our laboratory cultures from practically every sample of chinch bugs brought in from their dormant winter quarters. In the succeeding years, which have been characterized by diminishing numbers

of chinch bugs during the crop season, the number of isolations of the chinch bug fungus has steadily decreased. And it has been remarkable that, during the winter just past, chinch bugs taken in dormancy in certain localities have yielded not so much as a single instance of the chinch bug fungus.

In the same connection, this also is of interest. In the late winter and early spring of 1936, the list of fungi isolated from chinch bugs was dominated by a type known as *Chaetomium*. Isolations are likewise made in our laboratory from diseased plants, particularly diseased trees, and it was a striking and noteworthy fact that during the same period the same fungus was commonly and abundantly isolated from diseased bark of trees, thus indicating some circumstance favorable to the development of this particular kind of fungus.

In succeeding years, *Chaetomium* has rarely been obtained in culture, but so far as the chinch bug work is concerned there has been a complete change of complexion in the lists of fungi obtained. It is significant that during the present late winter and spring we have not once obtained the Chaetomium fungus in culture. However, the greatest abundance of fungi tend to be those most definitely considered saprophytic and includes especially members of the two genera, Penicillium and Aspergillus. Whether this change in fungus flora accompanying chinch bugs in their winter quarters portends a renewed outbreak of chinch bugs dangerous to economic crops remains of course to be proved, yet the suggestion is very apparent that such may be the case.

While the points that have been brought out in the foregoing are not in the nature of exact and measurable data such as can be obtained and tabulated from laboratory experiments, it seems to me that they have an exceedingly important bearing upon the manner in which fungi should be regarded from the point of view of the ecologist. There is definite indication that certain types of fungi, particularly those which display the phenomenon known as heteroecism, may propagate themselves quite independently of alternate hosts and, in doing so, become controlling factors in determining the population of the plants upon which they are parasitic. This relationship applies not merely to plants economically important but particularly and especially to plants of interest and value from the purely scientific point of view. The inference is that fungi deserve a place in the thought of the ecologist, whether plant or animal, considerably larger than has hitherfore been accorded them.

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[1] Craigie, J. H. Discovery of the function of the pycnidia of the rust fungi. Nature 120:765-767. 1927.

[2] Sappin-Trouffy, T. Recherches histologiques sur la famille des Urédinées. Le Botaniste 5:59-244. 1896.

[3] Blackman, V. H. On the fertilization alternation of generation and general cytology of the Uredineae. Ann. Bot. 18:323-375. 1904.

Verticillium albo-atrum, Cosmopolitan Tree Parasite

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Wilting of trees by *Verticillium albo-atrum* R. & B. was first reported in the United States in 1914[1] on maple. It was first reported in Illinois in 1926.[2] Since 1926, *V. albo-atrum* has been associated with the wilting of other shade trees and ornamental shrubs.

Since the Natural History Survey began its intensive study of tree diseases in 1931, *V. albo-atrum* has been cultured from diseased parts of the following twelve hosts: *Acer platanoides* L., *A. nigrum* Torr. & Gray, *A. rubrum* L., *A. saccharum* Marsh., *A. platanoides Schwedleri* Kock, *Catalpa speciosa* Warder, *Prunus communis* Fritsch, *Rhus cotinus* L., *R. glabra* L., *Robinia Pseudo-Acacia* L., *Ulmus americana* L., and *Viburnum Lantana* L. I have been unable to find any previous report of Verticillium wilt of *Catalpa speciosa* Warder, *Robinia Pseudo-Acacia* L., and *Viburnum Lantana* L.

Symptoms on Catalpa, Robinia, and Viburnum are similar to those on Acer and Ulmus. There is the sudden or rapid wilting of individual branches or of the whole plant. This is characteristic of Verticillium wilt. The internal symptom is a colored streaking of the wood, characteristically fine and brown in elm (Figure 2), and from fine and green to solid green discoloration in maple (Figure 5).

In Catalpa pinkish-purple streaks form in the sapwood and turn blueish-brown when dried. In close proximity many fine, short streaks form one large, continuous streak in diseased tissue, and solid discoloration may involve entire rings in recent year's growth (Figure 6). In Robinia, Verticillium infection is characterized by fine, short, reddish-brown streaks promiscuously scattered throughout the infected wood (Figure 4). Coalescing of many fine discolored streaks to form large streaks or bands of discoloration in the wood has not been observed in Robinia. In Viburnum, Verticillium was isolated from light to dark reddish-brown wood, which showed very little evidence of streaks. In the cross section in Figure 3 this discoloration is shown to be localized mostly in one side of the stem.

Cultural characteristics have been studied for 9 Verticillium isolations: from *Acer platanoides*, 541-A and C; from *A. saccharum*, V-P.; from *A. nigrum*, 571; from *Catalpa speciosa*, 567; from *Prunus communis*, V-P-C; from *Rhus glabra*, 583; and from *Ulmus americana*, 568 and 574. All except two, V-P and V-P-C, were secured during 1936. Each isolate was grown on 3 agars, cornmeal, potato dextrose, and malt extract. Growth characteristics and diameters were recorded at two-day intervals for sixteen days.

On potato dextrose all isolates except 568 produced a luxurient aerial weft of mycelium, which made the whole colony appear white, compact, and dense. Isolate 568 produced gray aerial mycelium. Characteristic sclerotia were produced by all isolates, and concentric zonation was shown by 541-C, 571, 567, V-P-C, and 583. Light and dark V-shaped regions were conspicuous in cultures of V-P and 541-A.

On corn meal (Figure 1) growth was sparse in contrast to that on potato dextrose. This was due mainly to the absence of dense aerial mycelium. Production of black sclerotia occurred in all cultures except 574 and 541-A, and concentric zonation was conspicuous except in 574. V-shaped regions were evident in cultures 541-C, V-P-C, and 568. Isolates 574 and 541-A produced hyaline, sparse surface and subsurface growth with practically no evidence of aerial mycelium. All other isolates produced black surface and subsurface growth, which resulted from the production of abund-

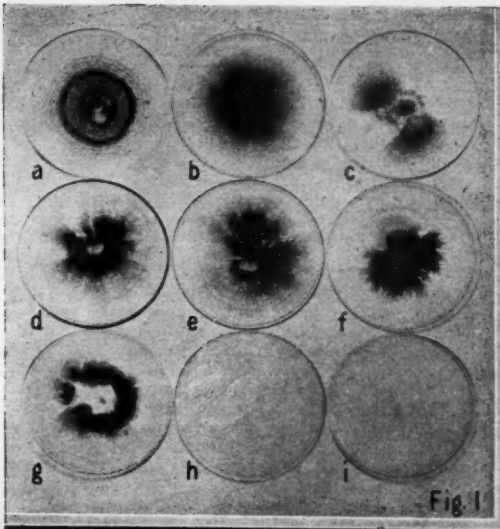

Fig. 1

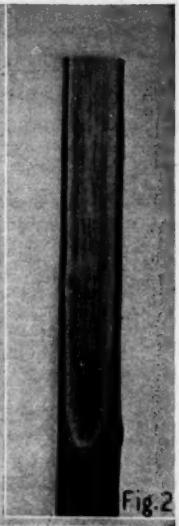

Fig. 2

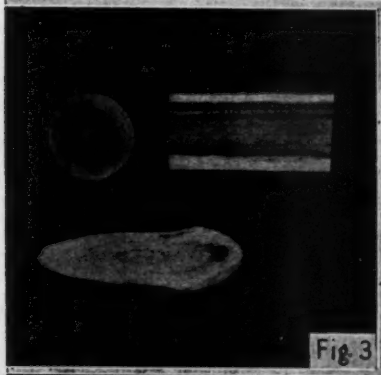

Fig. 3

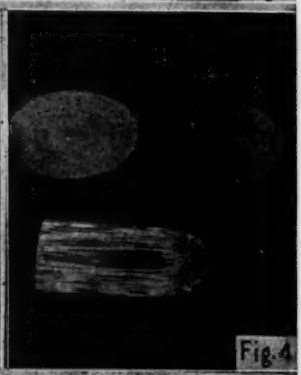

Fig. 4

Fig. 5

Fig.

ant, black sclerotia, and very few scattered, white aerial hyphae were present. A 4.7 mm. growth of white surface and subsurface hyphae made up the periphery of each colony.

The mycelial development of each isolate was most sparse on malt extract where aerial hyphae were hardly noticeable. Sclerotia were produced by all isolates except 541-A. Concentric zonation was present in V-P and 574. V-shaped regions of light and dark hyphae were produced by isolates 574, V-P-C, 583, and V-P. All isolates except V-P and 568 produced the greatest diameter growth in 16 days on corn meal (Table I). However, the total diameter growth of isolate 568 was 36.5 mm. on cornmeal and 36.8 mm. on potato dextrose. With the exception of isolate 583, the smallest diameter

TABLE I—DIAMETER GROWTH OF VERTICILLIUM ON 3 KINDS OF AGAR IN 16 DAYS

Isolate	Diameter growth in mm.		
	Potato dextrose	Corn meal	Malt extract
Acer platanoides (541-A)	50.5	61	48.3
A. platanoides (541-C)	43.8	49	43.5
A. saccharum (V-P)	48	43	42
A. nigrum (571)	40.5	53.5	34.5
Catalpa speciosa (567)	49	54	40.3
Prunus communis (V-P-C)	40.5	55	40.3
Rhus glabra (583)	48.3	51.8	50.8
Ulmus american (568)	36.8	36.5	19
Ulmus american (574)	50.8	72.5	50.3

growth in 16 days occurred on malt extract. The diameter growth of isolate 583 on all three types of agar differed slightly, 51.8 mm. on corn meal, 48.3 mm. on potato dextrose, and 50.8 mm. on malt extract.

The aerial hyphae produced by the several isolates on all three types of agar were white, except that 568 produced gray aerial hyphae on potato dextrose. Surface mycelium of each isolate grew more or less radially outward from the inoculum on each type of agar. Sclerotia typical of *Verticillium albo-atrum* were produced by all isolates on potato dextrose, by all except 541-A and 574 on corn meal, and by all except 541-A on malt extract.

[1] Rankin, W. H. Thrombotic diseases of maple. Phytopath. 4:395-396. 1914.
[2] Gravatt, G. F. Maple wilt. U. S. D. A. Cir. 382:2. 1926.

EXPLANATION OF PLATE

Fig. 1.—Nine Verticillium isolates on corn meal agar: a, sumac; b, catalpa; c, Norway maple; d, almond; e, black maple; f, american elm; g, hard maple; h, american elm; i, Norway maple.

Figs. 2-6.—Characteristic wood discolorations in several hosts due to Verticillium attack: 2, *Ulmus americana;* 3, *Viburnum Lantana;* 4, *Robinia Pseudo-Acacia;* 5, *Acer platanoides;* 6, *Catalpa speciosa.*

Diplodia Ear Rot in Illinois Cornfields

G. H. Boewe

State Natural History Survey, Urbana, Illinois

Diplodia[1] ear rot or dry rot of corn occurs annually in Illinois cornfields, but its severity varies and it does not become a serious problem in most seasons, as shown in a previous paper.[2] While examining corn for diseases in the fall of 1937, the writer was impressed by the few times dry rot was found in the fields which were examined.

A varying amount of time has been spent each fall during a 10-year period, beginning with 1928 and extending through 1937, in studying cornfields to determine the prevalence of ear rots in the field before harvest. Cornfields in various parts of the State were examined each year, but the greatest number was examined in the central section, where the largest acreage is grown. The number of fields visited has varied between 20 in the fall of 1928 and 78 in 1935, and the number of ears examined has ranged between 3,800 in 1928 and 15,880 in 1935. Usually 200 ears were observed in each field, although this number varied from 100 to 500 ears. A summary of the 10 year's data is shown in Table 1.

During this period the prevalence of visible dry rot infection has ranged between a low of 0.14 percent in 1937 and a high of 5.88 per cent in 1930.

TABLE I—SUMMARY OF DIPLODIA EAR ROT DATA TAKEN ANNUALLY IN ILLINOIS CORN FIELDS DURING THE 10 YEARS, 1928-1937

Year	Number of ears examined	Ears infected		Number of fields examined	Fields with infected ears	
		Total	Per cent		Total	Per cent
1928	3,200	22	0.58	18	10	55.55
1929	11,900	178	1.49	36	35	97.22
1930	5,800	341	5.88	41	36	87.50
1931	10,850	63	0.58	44	19	43.18
1932	7,805	104	1.33	54	43	79.63
1933	9,200	260	2.83	50	42	84.00
1934	13,660	190	1.39	71	61	85.91
1935	15,880	61	0.38	78	46	58.97
1936	11,900	48	0.40	64	27	42.19
1937	12,600	18	0.14	63	8	12.70
Total	102,795	1,285		519	327	
10 year average			1.25			63.00

The average for the 10-year period is 1.25 percent. In 5 of the 10 years, the percentage of ears found with visible infection was above the average and in the other 5 years the percent of infection was below the average. In 3 particular years, 1931, 1936, and 1937, dry rot was found in less than 45 percent of the fields examined. In 1937, it was found in only 12.7 percent of the fields.

The author made a study of the occurrence of dry rot infected ears in the three sections of the State, north, central and south, recognized by the Weather Bureau, and found, as shown in Table 2, that on an average during the 10 years, 1.12 percent were infected in the north, 1.33 percent in central Illinois, and 1.19 percent in the south. Heaviest loss occurred in the central

TABLE II—SUMMARY OF DIPLODIA EAR ROT DATA OBTAINED FROM FIELD EXAMINATION OF CORN, 1928-1937

Section of State	Total number of ears		Per cent of ears with diplodia
	Examined	With diplodia	
North	26,430	295	1.12
Central	57,665	767	1.33
South	18,700	223	1.19

section, where the greatest acreage of corn is grown. Since dry rot infection is known to result from spores produced in old corn stalks and carried as far as 350 feet by the wind, this is to be expected if an abundance of inoculum is a criterion. For in this section, a large percentage of the corn acreage is planted on land which was in corn the previous season, and it is impossible in farm practice to eliminate all diseased stalks of the previous year.

There are other factors, however, which affect the prevalence and distribution of dry rot in Illinois cornfields. It was estimated[3] that 15 percent of the 1937 acreage was planted with hybrid seed and that this is 5 times as much as was planted in 1936. The low percentage of Diplodia ear rot found in the fall of 1937 is coincident with the increase in hybrid corn acreage.

[1] *Diplodia zeae* (Schw.) Lev. and not *Diplodia macrospora* Earle of the southern states.

[2] Boewe, G. H. 1936. The relation of ear rot prevalence in Illinois corn fields to ear coverage by husks. Ill. State Natl. Hist. Surv. Biol. Notes 6:1-19. May 20.

[3] These figures are estimates given the writer in conversation with Prof. C. M. Woodworth, of the Agronomy Department, University of Illinois.

The Production of Roots by Cuttings of Annual Plants Under the Influence of Indole-Butyric Acid

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Numerous experiments have been performed upon root production in cuttings of herbaceous and woody perennials after treatment with indole-butyric acid. Few experiments, however, have been carried out concerning the action of this acid upon root production in cuttings of annual plants, which normally do not produce roots from cuttings or produce roots in such small quantities that vegetative propagation of such plants by florists is impossible. The authors have placed cuttings of the following plants in solutions of various concentrations of indole-butyric acid to study possible effects on root formation: dwarf bush bean, Alaska pea, sweet pea, marigold, annual forget-me-not, didiscus, calendula, cineraria, and African strawflower *(Helipterum roseum)*. The source of indole-butyric acid employed was a commercial preparation known as "Auxilin," manufactured by the Pennsylvania Chemical Corporation.

The cuttings of the various species were placed in the solutions made by adding definite quantities of the acid to portions of dechlorinated tap water, for periods of 6 hours, 12 hours, 18 hours, 24 hours, and 36 hours. After these periods of partial immersion, the cuttings were placed in well-washed moist sand in flats, and were observed from time to time for root production. In most cases where the treatment was effective, root production began about 6 to 8 days after treatment.

None of the species used produced roots after 6 hours treatment. After the 12-hour treatment, the forget-me-not and bean cuttings produced a few roots, but in no case did the roots appear in sufficient numbers to support the continued growth of the cutting. The 18- and 24-hour treatments resulted in the production inside of 9 days of numerous, fast-growing roots in the cuttings of bean, cineraria, African straw-flower, forget-me-not, marigold, and calendula. There was no apparent difference in the results of the 18- and 24-hour treatments. The 36-hour treatment resulted in extensive rotting. No roots were produced at any time in any of the treatments in cuttings of sweet pea, Alaska pea, and didiscus. Figures 1 and 2 show the appearance of treated and untreated cuttings of bean, marigold, and forget-me-not after 14 days growth in moist sand.

The concentrations of indole-butyric acid employed were ½, 2, 4, 6, 8, and 10 mg per 100 cc of water. The ½ mg concentration was ineffective in root production, the 2 mg. concentration induced moderate root formation in the bean, forget-me-not, and marigold, but none in the other species. The 4 mg. concentration was most effective in those species mentioned above in which root formation occurred. With higher concentrations of the indole-butyric acid, the tendency toward rotting increased, although some root production did occur.

The results may be summarized as follows:

1. Rapid rooting of cuttings of calendula, marigold, forget-me-not, cineraria, bean, and African straw-flower may be induced after treatment with indole-butyric acid.
2. The optimum time of treatment is 18-24 hours.
3. The optimum concentration is 4 mg. of indole-butyric acid per 100 cc. of water.

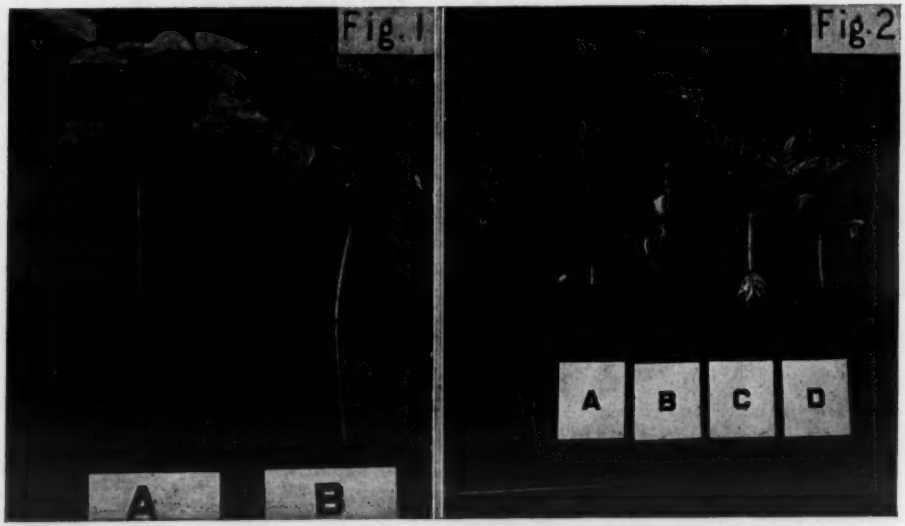

Fig. 1.—Beans: Treated cutting at left, untreated at right.
Fig. 2.—A and C: Treated forget-me-nots and marigolds.
B and D: Untreated forget-me-nots and marigolds.

Forest Distribution in Crawford County, Illinois

S. Ray Bradley

Robinson, Illinois

Crawford County is one of those in the eastern tier of Illinois counties bordered on the east by the Wabash River with its extensive terrace and bottomlands. The Embarrass bottom which is one to two miles wide crosses the southwest corner of the county. This bottom is not so well drained; so it affords an excellent place for the more southern tree species, especially those of the southwestern coastal plains region.

The prairie area and loess deposit makes a notable eastwest change. These factors make the county strategic as a transitional area.

The writer wishes to acknowledge the guidance of Dr. A. G. Vestal and the aid of Dr. William Trelease and Mr. S. H. Eaton in identifying tree species. For thorough locations and discussions see Master's thesis (1) in the University of Illinois Library.

Annotated List of Tree Species

(Crawford County, Illinois)

Plant names used are mostly those of Gray's Manual, edition 7. In a few cases the names used are those given in Deam's Trees of Indiana (2) or in Eaton's list for Lawrence county (3).

Abbreviations and symbols used:

Habitat	Distribution
X —Xeric	a —Abundant
XM—Xeromesic	f —Frequent
M —Mesic	i —Infrequent
HM—Hydromesic	lf —Locally frequent
U —Upland	la —Locally abundant
B —Bottomland	s —Scattering
T —Terrace	r —Rare
S —Swampy ground	w —Weed Tree
SB —Stream banks	sev—Several
WR—Wide ranging	ld —Locally dominant

Pinaceae

Juniperus virginiana L. Red cedar. XM. s.

Salicaceae

Populus grandidentata Michx. Tooth-leafed aspen. U., only three groups.
Populus deltoides Marsh. Cottonwood. B. f. & la.; U. i.
Populus heterophylla L. Swamp cottonwood. S. la. i.
Populus alba L. Silver poplar. U. e. f.
Salix nigra Marsh. Black willow. SB. f.
Salix longifolia Muhl. Sandbar willow. SB. f.
Salix discolor Muhl. Pussy willow. S. f.
Salix humilis Marsh. Prairie willow. U. s. clumps.
Salix sericea Marsh. Silky willow. Moist B. r.
Salix cordata Muhl. Heart-leaf willow. SB. i.
Salix alba L. European white willow. Introduced, one location.

Juglandaceae

Juglans nigra L. Black walnut. WR. f.
Juglans cinerea L. Butternut. M. i.
Carya pecan Asch. & Greene. Pecan. B. la.
Carya cordiformis K. Koch. Bitternut, yellowbud hickory. U. f. & la.; B. i.
Carya ovata (Miller) K. Koch. Shellbark hickory. WR. f.

Carya Laciniosa (Michx. F.) Loud. Kingnut, big shell bark hickory. B. f.; M. i.
Carya alba (L.) K. Koch. White hickory, big-bud hickory, mockernut. U. f.
Carya ovalis (Wang.) Sarg. Small-fruited hickory. U. i.; T. r.

Betulaceae
Carpinus caroliniana Walter. Hornbeam. M. lf., S. B.
Ostrya virginiana K. Koch. Ironwood. Sev. trees one location only. SB.
Betula nigra L. Black birch. In. B. lf. and la.; poorly drained U. i.

Fagaceae
Fagus grandifolia Ehrh. Beech. M. la. f.; B. i.
Quercus alba L. White oak. U. extremely frequent. B. i.
Quercus muhlenbergii Engelm. Chinquapin oak. U. i., s.
Quercus alexanderi Britton. Broad-leaf chinquapin oak. M. f.
Quercus bicolor Willd. Swamp white oak. B. f. la.; poorly drained U. f.
Quercus stellata Wang. Post oak. U., f.
Quercus macrocarpa Michx. Bur oak. M. s., poorly drained U.
Quercus imbricaria Michx. Shingle oak. U. f.; B. i.
Quercus borealis maxima Ashe. Red oak. M., U. and T.; f.
Quercus palustris Muench. Pink oak. B. and S. U. a., f.
Quercus schneckii Britton. Schneck's red oak. B. and T., i.
Quercus velutina Lamarck. Black oak. U. XM., f., la.
Quercus marilandica Muench. Black jack oak. U. X. XM., i.

Ulmaceae
Ulmus americana L. White elm. Very common. f. on SB. w.
Ulmus fulva Michx. Red elm. M. a.; XM. i.
Celtis occidentalis L. Hackberry. Moist B. f.
Morus rubra L. Red mulberry. M. f., SB.
Maclura pomifera (Raf.) Schneider. Osage orange. B. w. e.

Magnoliaceae
Liriodendron tulipifera L. Tulip tree. B., T., and M. slopes f. in denser woods.

Anonaceae
Asimina triloba (L.) Dunal. Dapaw. M. woods.
Understory tree.

Lauraceae
Sassafras officinale Nees & Eberm. U. M. f. la. w.

Hamamelidaceae
Liquidambar styraciflua L. Sweet gum. Rich B. a.; i. north part.

Platanaceae
Platanus occidentalis L. Sycamore. B. f. and la.; U. i.

Rosaceae
Pyrus coronaria L. American crabapple. f. especially north part.
Pyrus ioensis (Wood) Bailey. Western crabapple. f. over entire county.
Amelanchier canadensis (L.) Med. Service berry. U. M. i.
Crataegus crus-galli L. Cock-spur thorn. B. and T. f.
Crataegus mollis (Torrey & Gray) Scheele. Red haw. U.; B., and T. f.
Crataegus viridis L. Greenhaw. B. i.
Crataegus phaenopyrum (L. fils) Med. r.
Prunus americana Marsh. Wild plum. B. a.; U. i. la.
Prunus munsoniana Wright & Hedrick. i.
Prunus angustifolia Marsh. Chickasaw plum. r.
Prunus serotina Ehrh. Black cherry. .w. f.

Leguminosae
Cercis canadensis L. Red bud. SB. f. in rich moist woods.
Gymnocladus dioica K. Koch. Kentucky coffee tree. M. i.
Gleditsia triacanthos L. Honey locust. B. and well drained U. f. thornless variety (inermis) f. in B.
Robinia pseudo-acacia L. Black locust. U. f. e.
Ailanthus altissima (Miller) Swingle. Tree of heaven. r. e.

Aceraceae
Acer negundo L. Box elder. B. f.
Acer saccharinum L. Soft maple. B. f. a., and ld.
Acer rubrum L. Red maple. B. f.
Acer saccharum Marshall. Sugar maple. M. f. & a. variety *rugelii* Rehr. f.
Acer nigrum Michx. Black maple. B. r.

Xapindaceae
Aesculus glabra Willd. Ohio buckeye. B. r. only two trees.

Tiliaceae
Tilia glabra Vent. Bass wood. SB. and ravine slopes. i.

Cornaceae
Nyssa sylvatica Marsh. Black or sour gum. M. juvenile form. i.; XM. lf.
Cornus florida L. Flowering dogwood. M. woods f.
Cornus asperifolia Michx. Rough-leaf dogwood. i.
Cornus racemosa Lamarck. Gray dogwood. i.
Cornus obliqua Raf. Pale dogwood. i.

Ebenaceae
Diospyros virginiana L. Persimmon. U. & B. forest i.; U. w. f.

Oleaceae
Fraxinus americana L. White ash. M., SB., & B. f.
Fraxinus biltmoreana Beadle. Biltmore ash. B. r.
Fraxinus lanceolata Borckh. Green ash. B., HM. f.
Fraxinus pennsylvanica Marsh. Red ash. B. S. r.

Fraxinus profunda Bush. Pumpkin ash. B. S. lf.
Fraxinus nigra Marsh. Black ash. B. S. l. even r.
Bignoneaceae
Catalpa speciosa Engelm. Very few native. e. f. & s.

MORE IMPORTANT SHRUBS

Viburnum prunifolium L. Black haw. M. B. f.
Corylus americana Walt. Hazel. X. f. w.
Benzoin aestivale (L.) Nees. Spicebush. M. B. woods f.
Hydrangea arborescens L. Smooth hydrangea. M. woods, i.
Amorpha fruticosa L. Indigo bush. Treeless SB. a. near Wabash.
Zanthoxylum americanum Miller. Prickly ash. r.
Rhus copallina. L. Rough sumac. a. w.
Staphylea trifolia L. Bladdernut. Moist forest i.
Cephalanthus occidentalis L. Buttonbush. B. S. a.
Sambucus canadensis L. Elder. U. s.

SUMMARY

This area is the northern part of what Ridgway (5) described as one of the most luxuriant areas of deciduous forest in the world—the lower Wabash Valley.

The range of Schneck's Red Oak (*Quercus schneckii* Britton), swamp cottonwood (*Populus heterophylla* L.), black maple (*Acer nigrum* Michx), Ohio buckeye (*Aesculus glabra* Vent) and pecan (*Carya pecan* Asch and Greene) is extended by this work.

Species found in the county which are not sufficiently identified for inclusion in the above list are: two willows, several hawthorns, at least one ash and a few wild plums.

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Bark Growth in Tropical Trees

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As LaRue (1932) has pointed out, botanists have neglected the study of bark and as a result know relatively little about that portion of woody stems. LaRue (1920) has made measurements upon bark thickness in some temperate zone trees and in the Para rubber tree, *Hevea brasiliensis*. Among his conclusions he has emphasized the rather striking correlation between bark growth and total trunk growth in diameter in temperate zone trees, and the relatively low correlation between bark thickness and total trunk growth in the Para rubber tree.

During a recent collecting trip to Trinidad and Dutch Guiana, the author made a number of measurements upon bark thickness of native and introduced tree species. These measurements of bark thickness and wood diameter were made at 1 meter above the ground. The results are presented in figures 1 and 2. In each group of bars, each bar represents one tree; each group of bars, then, represents measurements on different trees of different sizes in the same species. In figures 3 and 4 are presented measurements made in 1935 of bark thickness and wood diameter of common north temperate zone trees. In figure 5, each group of bars represents measurements on the *same* tree. The greatest diameter is that of the main trunk at 1 meter above the soil line, the lesser measurements are those of branches of the same tree.

The tropical species measured were *Hura crepitans, Pithecolobium saman, Tamarindus indica, Chrysophyllum cainito, Cynometra trinitensis, Couroupita guianensis, Guaiacum officinale, Colvillea racemosa, Cedrela mexicana, Cordia alliodora, Tectona grandis,* and *Erythrina micropteryx.* The temperate zone trees investigated were *Betula lutea, Acer saccharum, Populus deltoides, Populus tremuloides, Quercus borealis, Quercus macrocarpa, Juglans nigra,* and *Ulmus americana.* Because of space limitations, it is possible to present data on only a portion of these species.

A study of the graphs leads to these conclusions:

1. The bark of the tropical trees measured is significantly thinner in proportion to wood diameter than is the bark of the temperate-zone trees measured.

2. The bark of the temperate-zone trees increases in thickness at a rate roughly proportionate to the rate of increase in diameter of the wood. In the tropical trees, the rate of bark increase is far lower in proportion than that of wood increase.

3. In the tropical trees studied, the thickness of bark above 1 meter from the soil line varies but little on the trunk and main branches. Only upon the branches of the third and fourth order is the bark significantly thinner.

The author wishes to express his appreciation of a grant from the Graduate School Research Board of the University of Illinois which paid, in part, collecting expenses of his West Indian trip.

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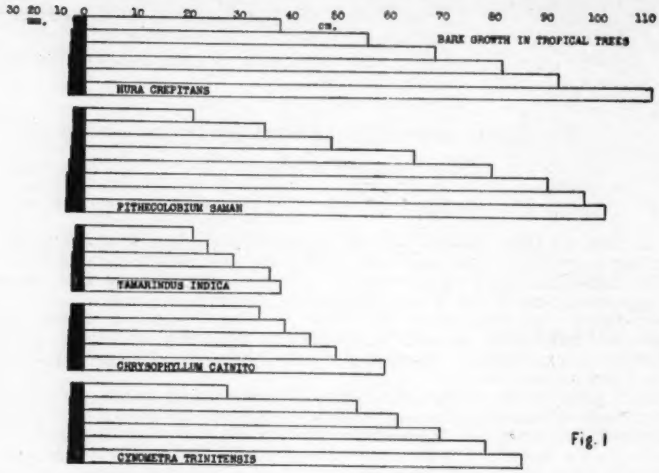
30 20 10 0 10 20 30 40 50 60 70 80 90 100 110
mm. cm.
BARK GROWTH IN TROPICAL TREES
HURA CREPITANS
PITHECOLOBIUM SAMAN
TAMARINDUS INDICA
CHRYSOPHYLLUM CAINITO
CYNOMETRA TRINITENSIS

Fig. 1

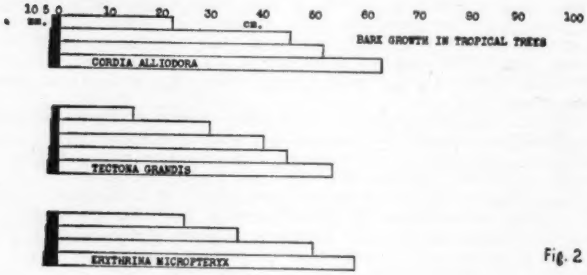
10 5 0 10 20 30 40 50 60 70 80 90 100
mm. cm.
BARK GROWTH IN TROPICAL TREES
CORDIA ALLIODORA
TECTONA GRANDIS
ERYTHRINA MICROPTERYX

Fig. 2

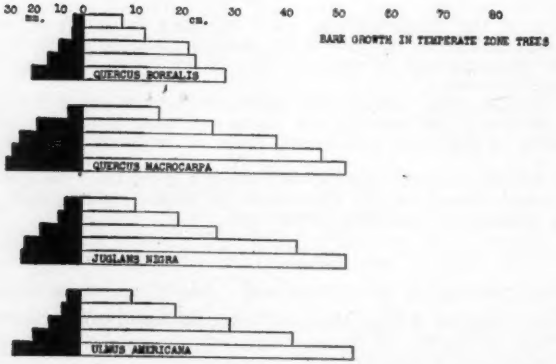
30 20 10 0 10 20 30 40 50 60 70 80
mm. cm.
BARK GROWTH IN TEMPERATE ZONE TREES
QUERCUS BOREALIS
QUERCUS MACROCARPA
JUGLANS NIGRA
ULMUS AMERICANA

Fig. 3

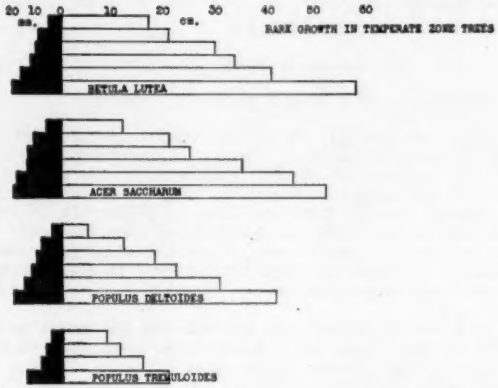

Fig. 4

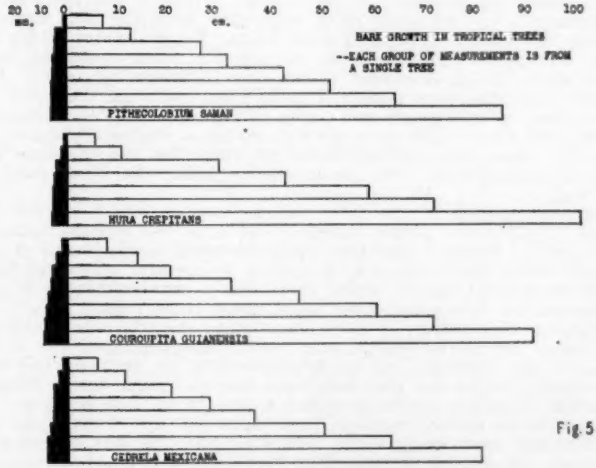
20 10 0 10 20 30 40 50 60 70 80 90 100
mm. cm.
BARK GROWTH IN TROPICAL TREES
--EACH GROUP OF MEASUREMENTS IS FROM A SINGLE TREE
PITHECOLOBIUM SAMAN
HURA CREPITANS
COUROUPITA GUIANENSIS
CEDRELA MEXICANA

Fig. 5

(In the graphs, the shaded portions of the bars represent bark thickness in mm., the unshaded portions, wood diameter in cm.)

Growth Rings of the Oak as Related to Precipitation in Illinois

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The investigations of Douglas (1) on the relation between the width of the growth rings of western conifers to climatic phenomena are now well known. Within the range of the eastern deciduous forests several investigators have shown a correlation between tree ring width and precipitation. Among the more recent contributions are those of Diller (2) on the beech in Indiana; Lyon (3) on the pines and hemlocks of New England; Robbins (4) on the oaks in Missouri; and Lyons (5) on the oaks and cottonwoods of Iowa. The reports of other investigators are cited in the bibliographies of the authors mentioned above, but no one seems to have investigated any of the trees of Illinois.

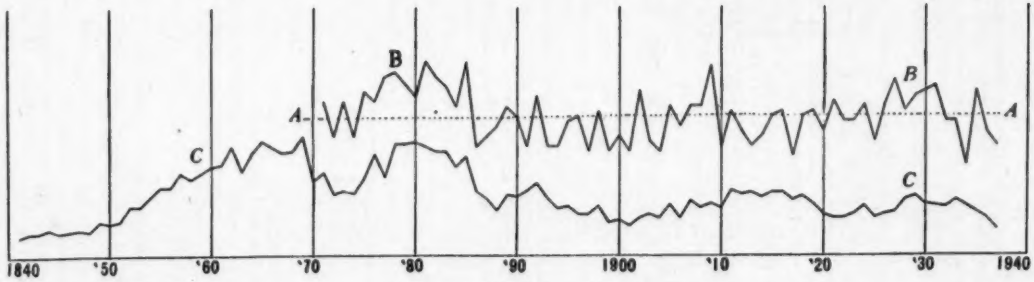
During the past year an opportunity was afforded the writer to examine a section of a red oak, *Quercus borealis*, grown in an open stand on morainic upland soil, on the Chicago Tribune Farm near Wheaton, DuPage County, Illinois. The tree was about 29 inches in diameter, three feet from the ground. It had produced some leaves in the spring of 1937, but had died, from unknown causes, later in the summer. When it was cut down in the late autumn a section made about three feet from the soil permitted the counting and measuring of the growth rings. The smoothing of the cut surface by a carpenter's plane and the application of white shellac to the planed surface made the measurement of the rings comparatively easy. Under a magnifier the rings were measured along three radii and the width of each ring recorded in millimeters and tenths of millimeters. The averages of the data for the three radii were plotted, giving a fluctuating growth curve. Ninety-six rings were distinguishable showing that the tree was approximately a century old. The measurements along the three radii agreed fairly well.

The life history of the tree may be divided into four well marked periods. The seedling period extended over some two decades during which the growth in diameter increased from one-tenth to one-fourth of an inch per year. This was followed by a sapling or youthful tree stage extending over three decades during which there was a maximum rate of increase in diameter, an inch being added about every third year.

Maturity may be said to have begun when the tree was a half century old. Under normal conditions this would have continued for at least a century in the red oaks but in this individual an untimely end came in four decades before the tree had lived half its usual span. During this middle life diameter-increase averaged a fifth of an inch per year.

A premature decline seems to have begun with the drought years of the early 30's and death occurred in 1937 when the tree was approximately a century old, for since 96 growth rings were counted it is safe to assume that the seedling was at least four years old before it reached the height of three feet from the ground where the section of the trunk was made.

The rainfall records are from the Chicago Weather Bureau 30 miles distant. They began in 1871 and are plotted for the calendar year against a mean of 32.86 inches. Lyon and others have shown that the rainfall during the late winter and spring is most important for tree growth and that a closer correlation between growth and precipitation is obtained by using a year extending from October to September. It was thought, however, that for the purpose of this study the calendar year would be most convenient and sufficiently accurate.



LEGEND FOR FIGURE

Fig. 1. Correlation of precipitation and tree growth. Annual precipitation *(B)* plotted against mean annual precipitation *(A)*. Width of annual rings of oak tree *(C)*.

Comparing the graph representing precipitation with that representing growth one period of more than average rainfall centers about the year 1880 and during that period the growth response was marked. It was followed by more than a decade during which precipitation was below the mean and this too is reflected in the lowering of the growth curve for the decade ending about 1900.

If a closer analysis be made it will be found that for at least 46 of the 66 years for which the record is available there is a positive correlation between precipitation and growth as represented in the graphs. It is also evident that for some 10 other years the growth curve may be explained by the carry-over of the rainfall excess or deficiency from the preceding year.

We may conclude from this that in one instance a very close correlation is evident between the precipitation for the calendar year in Illinois and the increase in diameter in a red oak tree shown by the thickness of its annual growth ring.

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Comparative Anatomy and Angiosperm Phylogeny

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AN ABSTRACT*

This investigation was a study of some twenty-two families centering about the Moraceae and it had for its purpose the establishment of the phylogenetic relationships of these families. It was based primarily on a comparative anatomical study of the secondary xylem of the plants belonging to these families. Slides representing stems of one hundred and sixty-five genera and four hundred and sixty-five species were examined. In addition, the anatomical evidence derived from a study of the secondary xylem was harmonized with the evidence from floral anatomy, nodal anatomy, floral morphology, and the available evidence from the fields of paleobotany and cytology.

The Moraceae and allied families have been variously placed by the phylogenists who have based their systems for the most part upon floral morphology. Engler and Prantl and Wettstein place these families in the Amentiferae and they consider this collection of families to be the most primitive group among the Dicotyledons. On the other hand, Hutchinson, Bessey, and Hallier feel that the Ranales or Magnoliales are most primitive and therefore they consider the families in the Amentiferae to be rather highly specialized plants which have been derived from various other groups.

Now, on the one hand there are the diverse placements of these groups by the various phylogenists and, on the other hand, through the years the anatomists have worked out an extensive list of lines of specialization in the structures of the plant stele—primarily in the secondary xylem. It is thought by many that these lines or sequences in evolution can be employed in establishing a natural system of phylogeny.

These lines of specialization have been worked out for the evolution of vessel elements, fibrous tracheary elements, rays, wood parenchyma, and other structural features. The lines referred to have been established by Jeffrey, Bailey, Frost, Kribs, Record, Chalk, Sinnott, and some others. Space does not permit a discussion of the evidence upon which these lines of specialization are founded. It can be said, however, that they were established independent of any system of Angiosperm classification. They are not based on any preconceived notion that this or that group of Gymnosperms has given rise to the Angiosperms, or on any preconceived idea that the Ranales or the Amentiferae are primitive.

Now, let us turn to the anatomical descriptions of the various families to see which, if any, of these systems of phylogeny is favored by the anatomical facts.

In the Hamamelidaceae, most of the species have tracheids; vessel distribution is mostly solitary; the vessels are angular and thin-walled; the mean vessel diameter is 32μ; all the species have scalariform perforation plates on the vessel elements; the vessel element end walls are very oblique; the intervascular pitting is scalariform, transitional, and opposite in most of the species; the mean vessel element length is 1089μ; the rays are heterogeneous I or IIA in most; the wood parenchyma is diffuse in most species; and all the woods are diffuse-porous. The secondary xylem of this family is very close in all anatomical details to certain groups in the Magnoliales.

In the Casuarinaceae, the fibrous tracheary elements are tracheids; the pores are solitary for the most part; all the woods are diffuse-porous; the pores are angular in some species and angular to round in others; the vessel walls are thin; the mean vessel diameter is 88μ; most of the species have scalariform and simple perforation plates; the end walls on the vessel elements vary from 15° to 90°; the intervascular pitting is mostly opposite and alternate; the mean vessel element length is 412μ; the rays are heterogeneous IIB; and the xylem parenchyma is metatracheal in most. It is apparent that this family is rather highly specialized anatomically and therefore cannot be regarded as the most primitive, or among the most primitive, of the families of the Angiosperms—as it has often been considered by certain phylogenists.

In the Betulaceae, there are tracheids and fiber-tracheids; the pores are solitary and in multiples; all the genera are diffuse-porous; the vessels are angular in most; the walls of the pores are thin; the mean vessel diameter is 48μ; the perforation plates are exclusively scalariform in most species; some species, however, have simple with some vestigial scalariform plates; vessel end walls vary from 15° to 50°; intervascular pitting is alternate in most genera; the mean vessel element length is 608μ; the rays are heterogeneous IIB or homogeneous I; and the wood parenchyma is diffuse, terminal, metatracheal, vasicentric, or combinations of these. The Betulaceae are clearly on a higher plane of anatomical specialization than the Hamamelidaceae.

The Fagaceae are quite like the Betulaceae except that the former are higher than the latter anatomically.

In the Ulmaceae, there are fiber-tracheids and libriform wood fibers; vessel distribution is a combination of solitary pores, pore multiples, and pore clusters; the woods are diffuse-porous or ring-porous; the pores are angular and round; the walls of the vessels are thin, or in a few cases thick; the mean vessel diameter is 96μ; the vessel elements bear simple perforation plates or vestigial scalariform perforation plates; the vessel element end walls vary from 20° to 90°; the intervascular pitting is opposite and alternate; the mean vessel element length is 286μ; the rays are heterogeneous I, IIA, IIB, or homogeneous I; the wood parenchyma is usually a combination of terminal and vasicentric, or is aliform and confluent, or diffuse and vasicentric; and there is a tendency towards storied structure in a few species. It can be seen that the Ulmaceae are higher anatomically than the Hamamelidaceae. The vestigial scalariform perforation plates would seem to indicate that the Ulmaceae were derived from a family in which there were scalariform perforation plates on the vessel elements.

The Moraceae are anatomically similar, yet more specialized than the Ulmaceae. The Urticaceae are even more highly developed than the Moraceae.

The Rhoipteleaceae do not seem to belong in the Urticales for all the vessel elements are very long and have scalariform perforation plates.

The Eucommiaceae are in many ways intermediate in position between the Hamamelidaceae and the Urticales. The Eucommiaceae have latex, also.

Interpreting the anatomical data given for each family in the light of the lines of specialization in the structures of the plant stele which have been worked out by the anatomists, together with a consideration of the facts from floral and general morphology, the writer has come to the following conclusions concerning the phylogenetic relationships of the various orders and families studied in this investigation: 1. The Hamamelidaceae are derivatives of the Magnoliales. 2. The Casuarinales, the Fagales, and the Urticales are derivatives of the Hamamelidaceae. 3. In the Urticales, the Ulmaceae are most primitive, the Moraceae are less so, and the Urticaceae are least primitive.

In general it may be stated that the above phylogenetic scheme is supported by the greater part of the evidence from the fields of floral morphology, nodal anatomy, cytology, paleobotany, and floral anatomy.

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* A more complete account of this investigation is to be published elsewhere.

A New Cycadophyte and its Relatives*

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Recently a new type of *Medullosa* stem has been discovered in coal balls from the Clarkson Mine, (coal No. 6) at Nashville. This stem may best be compared with the three species of *Medullosa* which have been described from the English lower Coal Measures. These are *Medullosa anglica, M. centrofilis and M. pusilla* and the beds from which they are derived are considered roughly equivalent to the Pottsville series of the lower Pennsylvanian of this country. The new stem from Nashville consequently is younger geologically than the related European forms. In the accompanying drawings the author has attempted to reconstruct cross sections to scale as the stems would appear if uncrushed or undistorted. All three English species possess three separate main steles. No doubt the English forms are most closely related but their primary structures of determinate growth differ so much in size that they must all be considered valid species. *M. centrofilis* has a small centrally placed accessory stele which further distinguishes it. A band-like internal periderm layer between the stelar region and the cortex is consistently found in all three English forms.

Instead of three steles our new Nashville *Medullosa* has but two. The stem is somewhat larger than *Medullosa anglica* as may be noted on the plate since the drawings are approximately on the same scale. The decurrent petiole bases are essentially similar although their arrangement on the stem is different. Details of histology also differ showing that this form from Nashville is distinct and not simply a distelar aberration of a typically tristelar species. Perhaps the most noteworthy single feature is the extreme asymmetry of the two steles in this new species. The secondary wood is strongly developed on each vascular member toward the center but only slightly developed on the portion facing the stem exterior. Scott (1) has pointed out that this also occurs in *Medullosa anglica* and *M. pusilla.* Examination of De Fraine's figures of *M. centrofilis* show the same condition exists for it too, but in none of these species is the asymmetry of growth so extreme as in the Nashville stem. Whatever the cause for the preponderant secondary growth toward the center of the stem may be, its occurrence in all four of these species indicates that it has some definite significance. A band-like internal periderm layer is present enclosing the stelar tissues of the Nashville *Medullosa* as in the English stems.

Sutcliffia insignis has been suggested by De Fraine as representing a primitive type among the Medullosaceae from which the polystelar forms could have been evolved. A reconstruction (more tentative than the other sketches) obtained by combining features illustrated by Scott (2) and by De Fraine (3) is also included on the plate. *Sutcliffia* also possesses decurrent petioles, and a less well defined internal periderm band. There is but a single main vascular cylinder around which are a number of smaller stelar units. These latter structures give rise to the multitudinous small leaf trace bundles and on this account De Fraine regards them more as large foliar traces than as structures homologous with the central stele.

It might be inferred that the Nashville *Medullosa* is derived more directly from a *Sutcliffia* type of stem than any of the other species on account of its fewer steles, notwithstanding that our new form is of somewhat younger geologic age than any of the others mentioned. However it

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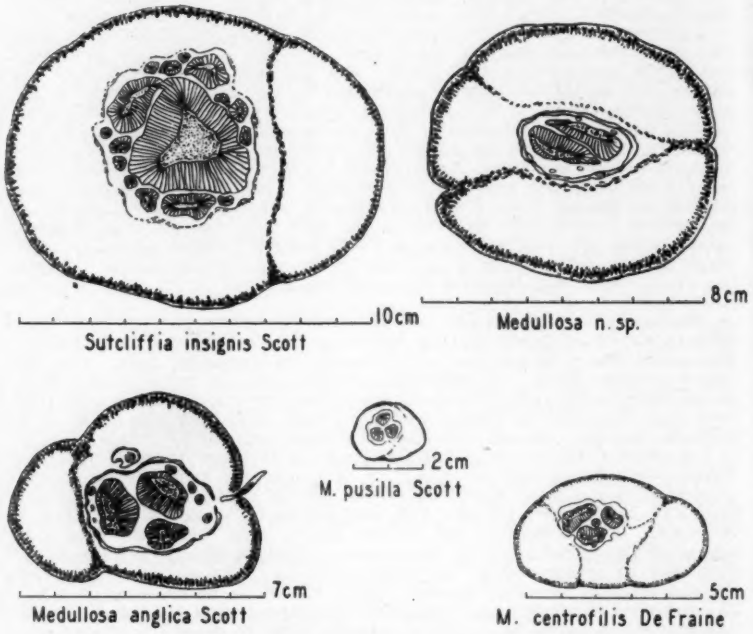
seems more likely that the reverse is the case since the asymmetry of the steles is probably a specialized feature and this is more extreme in the Nashville stem than in the English Medulloseae. The distelar condition may have come about by elimination of one of the steles of a tristelar form as easily as by the division of the stele of an essentially monostelar plant. The lesser number of steles in the Nashville *Medullosa* is a feature which serves to distinguish it specifically but this character is less important in itself for judging phylogenetic position. Reduction in complexity of general stelar organization seems more in keeping with features of the histologic organization which will be discussed elsewhere[4] in connection with a diagnosis of the new plant.



CROSS-SECTIONS OF STEMS OF CERTAIN MEDULLOSACEAE

These plants, whose stem structure is so different from those typical of the present are also known to have had fern-like foliage and large nut-like seeds. The male fructification in some instances at least was remarkably large with tubular sporangia containing male spores which are also much larger and very different from the pollen of modern plants. Even in the case of the best preservations these various organs are habitually found separate from one another. This renders it scientifically impossible to make certain of the specific correlation of seed structure, characters of the male fructification or of the stem or leaf in any single instance which would be comparable with that known for plants living today. We cannot know for certain whether allied stems of different ages with specifically different structure also had different seeds or whether the seed characters were about the same in both cases. The sex organs are considered to be

conservative by modern taxonomists so the last possibility might conceivably be of common occurrence in fossil plants. As a consequence of this general situation the identification of the genus *Medullosa* is based entirely on characters of the stem. Notwithstanding this handicap the leaves, petioles, seeds, male fructifications and roots which go with these stems are sufficiently known, either from isolated cases where the organs are found in actual connection or from their constant association in the same deposits or on the basis of histologic similarities, that their general relationship is apparent. Thus it is known that several *Medullosa* stems bore foliage which is classified separately as *Alethopteris*. Structurally preserved petioles detached from their stems are designated as *Myeloxylon*. The characters used in diagnosing species of either of these genera do not necessarily correlate in the course of evolution with species variations exemplified by the stems.

Recently fructifications which are related in the Medullosaceae have been discovered. Certain of the Medullosan seeds have been named *Rotodontiospermum* and male fructifications are classified under *Dolerotheca* (in part). It is necessary to use these different names to apply to the various isolated plant organs because their specific inter-correlation cannot be proved with sufficient accuracy. Herein lies the chief difference between the taxonomy of fossil and modern plants. It must be recognized nevertheless that these fossils classified under different names have a close natural relationship to the stems previously discussed. In various instances the relationship of assembled organs, as in the case of these mentioned, may be indicated by classifying them together in a more generalized category such as a family. The reconstructions of complete plants of past ages also are based on generalizations of this sort and they have proved a most effective means of summarizing our detailed knowledge of the fossil floras.

The foregoing discussion may serve to indicate briefly the problems involved in the paleobotanic study of Medullosaceae. The new stem from Nashville lends emphasis to characters which had previously received little attention. Of course a great deal of study will be necessary before the botanical peculiarities and the relationship of this interesting group of plants become fully known. It is definitely encouraging that additional specimens are being discovered in Illinois coal balls because the European specimens known previously left many pertinent questions unanswered.

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A List of the Lichens From Hardin County

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The lichens reported in this paper were collected in the Spring of 1937 by the writer. The collections were made from three regions: Hicks Dome, the ravine near the Boultinghaus Store at Sparks Hill, and the wooded area south of the Union School number four. The names used are those found in *The Lichen Flora of the United States* by Bruce Fink.

The following abbreviations are used to indicate the areas from which the specimens were collected:

H. D.....Hicks Dome
S. P.....Sparks Hill
U. S.....Union School

Lichens of Hardin County

PARMELIACEAE	
Parmelia borreri Turn	S.H.
physodes (L.) Ach.	U.S.
quercina (Willd.) Vainio	U.S.
rudecta Ach.	S.H.
conspersa (Ehrh.) Ach.	U.S., H.D.
perforata (Wulf.) Ach.	U.S.
sulcata Tayl.	U.S.
Cetraria ciliaris Ach.	U.S.
PELTIGERACEAE	
Peltigera canina (L.) Willd.	U.S.
spuria (Ach.) DC. in Lam. and DC.	U.S.
GRAPHIDACEAE	
Graphis scripta (L.) Ach.	H.D.
eulectra Tuck.	U.S.
lineola Ach.	U.S.
Phaeographis dendritica (Ach.) Müll.	H.D.
ARTHONIACEAE	
Arthonia lapidicola (Tayl.) Branth. and Rostr.	U.S.
dispersa (Schrad) Nyl.	U.S.
PHYSCIACEAE	
Physcia stellaris (L.) Nyl.	U.S., H.D.
pulverulenta (Schreb.) Nyl.	S.H.
Anaptychia speciosa (Wulf.) Mass.	S.H.
USNEACEAE	
Usnea barbata (L.) Wigg.	U.S.
PERTUSARIACEAE	
Pertusaria velata (Turn.) Nyl.	U.S.
multipuncta (Turn.) Nyl.	U.S.
pertusa (L.) Tuck.	H.D.
DERMATOCARPACEAE	
Dermatocarpon miniatum (L.) Mann.	U.S.
CLADONIACEAE	
Cladonia mitrula Tuck.	H.D., U.S.
sylvatica (L.) Hoffm.	S.H.
fimbriata (L.) E. Fries.	H.D., U.S., S.H.
pyxidata (L.) Hoffm.	H.D., U.S., S.H.
didyma (Fée) Vainio	H.D.
gracilis (L.) Willd., var. dilacerata Floerke.	S.H.

Basicladia in Illinois

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Basicladia, which grows on the backs of snapping turtles, has not yet been reported to occur in Illinois. Previous to this paper it had been identified three times in the laboratories of the University. The first was from a collection from an unknown source, the second from collections from the Polly-Wogs, a private fishing club in Vermilion County, Illinois, and the third from the Illinois River near Beardstown, Illinois.

Fig 1 *Basicladia chelonum* (Collins) Hoffman and Tilden comb. nov. *Maple Lake, Cook Co., Illinois*

This paper is based upon collections of algae found on the backs of turtles taken from Maple Lake, Cook County by Lynn H. Hutchins of the University of Illinois, August 8 to 19, 1937.

In June, 1909, F. S. Collins described a species of *Chaetomorpha chelonum* based on collections taken from the backs of turtles, *Chrysemys marginata*, and *Aronchelys odorata* in Michigan.

This fresh-water species was again found on turtles at Tewksbury, Massachusetts.

L. H. Tiffany, Ohio State University, collected and identified *Chaetomorpha chelonum* from the backs of turtles, *Chrysemys marginata belli*, Miller's Bay and Lake West Okoboji, Iowa, July and August, 1915 and again in 1923.

In the summer of 1923 collections were made at St. Peters, Minnesota by W. E. Hoffmann. The specimens proved to have very distinctive characteristics, but were easily traced to Collins' *Chaetomorpha chelonum*, except that branching occurred and the dimensions were much larger.

A second collection was made in Minnesota in 1926 from a shell of a turtle in the Zoological Museum of the University. Because of branching and the variation in size, Hoffmann and Tilden changed the genus from *Chaetomorpha* to *Basicladia* and recognized two species.

Basicladia crassa, Hoffmann and Tilden, sp. nov., upright filaments reaching a diameter of 50 to 120 microns. Collected from the shell of the snapping turtle, *Chelydra serpentia*, St. Peters, Minnesota, August 17, 1923.

Basicladia chelonum (Collins, Hoffmann and Tilden) comb. nov., (*Chaetomorpha chelonum*, Collins), upright filaments 45 microns or less in diameter. This species is known from only Michigan, Massachusetts, and Iowa.

The maximum diameter of the main filament of the *Basicladia* found in the Maple Lake collections never measured over 45 microns. It was identified as *Basicladia chelonum*.

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Recent Collections of Illinois Liverworts

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MARCHANTIALES

Conocephalum conicum (L.) Dum.
Jo Daviess Co. Miner's Gulley..... L 211 H
Peoria Co. Rocky Glen..... 1208 D
Tazewell Co. Spring Lake..... 1208 D
Vermilion Co. South of Oakwood..... L 211 H
Marchantia polymorpha L.
LaSalle Co. Starved Rock..... 1255 D
Jo Daviess Co. Apple River Canyon Park..... L 1 H
Preissia quadrata (Scop.) Nees.
Jo Daviess Co. Apple River Park..... L 2 H
Reboulia hemispherica (L.) Raddi
Hardin Co. ..... L 3 H
Riccia sorocarpa Bisch.
Champaign Co. Urbana..... 1286 D
Ricciella Sullivantii (Aust.) Evans..... 1252 D
Ogle Co. Oregon..... 1252 D
Ricciocarpus natans (L.) Corda.....
Jersey Co. Illinois River..... L 220 H

JUNGERMANNIALES

Aneura (Riccardia) penguis (L.) S. F. Gray
Tazewell Co. Spring Lake..... 1082 D
Aplozia (Jungermannia) caespiticia (Lind.) Dum.
Saline Co. Stillhouse Hollow..... L 200 H
Aplozia lanceolata L.
Pope Co. Dixon Springs..... L 219 H
Calypogea trichomanis (L.) Corda
Johnson Co. Fern Cliffe ..... L 202 H
Cephalozia bicuspidata (L.) Dum.
Union Co. Wolf Lake..... L 203 H
Cephalozia connivens (Dicks.) Lindb.
Saline Co. Stillhouse Hollow ..... L 210 H
Cephaloziella myriantha (Lindb.) Schiff.
Saline Co. Stillhouse Hollow..... L 246 H
Eucalyx hyalinus (Lyell.) Breidl.
Ogle Co. East of Oregon..... L 209 H
LaSalle Co. Starved Rock..... 1257 D
Frullania Asagrayana Mont.
Saline Co. Stillhouse Hollow..... L 208 H
Frullania eboracensis Gottsche
McLean Co. Funk's Woods..... L 207
Carroll Co. Smith Park..... L 206
Johnson Co. Swartz Hill..... L 223
Geocalyx graveolus (Schrad.) Nees.
Hardin Co. ..... L 4 H

Jamsoniella autumnalis (DD) Streph.
Champaign Co. University Woods..... 1267 D
Lophocolea cuspidata Limpr.
Carroll Co. Palisades ..... L 212 H
Tazewell Co. Lick Creek..... L 213 H
Union Co. Balcom..... L 216 H
Lophocolea heterophylla (Schrad.) Dum.
Champaign Co. University Woods..... 789 D
Hardin Co. ..... L 246 H
Lake Co. Lisle..... 517 D
Jo Daviess Co. Apple River Park..... L 222 H
Tazewell Co. Funk's Timber..... L 218 H
Vermilion Co. Oakwood..... L 217 H
Lophocolea minor Nees.
Tazewell Co. Morton..... 1221 D
Vermilion Co. Camp Drake..... L 220 H
Plagiochila undata Sull.
S. Illinois ..... 1043 D
Porella pinnata L.
Johnson Co. Vienna ..... L 232 H
Saline Co. Stillhouse Hollow..... L 233 H
Porella platyphylla (L.) Lindb.
Champaign Co. ..... 1261 D
Hardin Co. ..... L 231 H
Jo Daviess Co. Apple River Park..... L 224 H
Lake Co. Lisle. White Pine Park..... 1166 D
Marion Co. Joppa..... L 235 H
Ogle Co. Oregon..... 1258 D
Tazewell Co. ..... 1252 D
White Co. Norris City..... L 225 H
Radula complanata (L.) Dum.
Jo Daviess Co. Apple River Park..... L 201 H
Ptilidium pulcherrinum (Weber.) Hampe
Champaign Co. University Woods..... 1112 D
Scapania nemorosa (L.) Dum.
Johnson Co. Fern Cliffe..... L 238 H
Saline Co. Stillhouse Hollow..... L 240 H
Scapania undulata (L.) Dum.
Johnson Co. Fern Cliffe..... L 241 H
Saline Co. Stillhouse Hollow..... L 245 H

ANTHOCEROTALES

Anthoceros laevis L.
Peoria Co. Rocky Glen..... 1209 D
Anthoceros punctatus L.
Tazewell Co. Lick Creek..... 1211 D

ABBREVIATIONS

H—Collections of Stella M. Hague.
D—Collections of R. V. Drexler.
L—Liverwort.

College Grades in the Biological Sciences as Related to Secondary School Training

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For several years we have wondered whether the high school training in the biological sciences had much if any effect upon the grades made by students in our beginning college botany course. In order to substantiate or refute our subjective deductions that they had little effect we decided to make a comparison of grades. A comparison of grades may be a dangerous thing but if viewed in terms of generalities and not specific instances it should show the effect of previous training. To make this comparison we attempted to obtain the actual grade advantage if any for those students who had had some high school training over those having had no such biological experience in high school in their beginning general botany course. Grades for only a year of work or less in botany were considered.

The registrar at our college during the past two years has been placing all the grades of all the students that have been in attendance during these two years on new type record cards. As most of the students who have been in attendance during these years have made their grades within the last five years, we decided to limit our study to these students. Older records are available for former students but we wished to have our data of recent origin. The data we wish to present includes the grades of our present student body through the fall quarter of this school year.

On investigating the records of the registrar we decided to include the grades for zoology and the one-quarter course in hygiene. The number of students considered is 882. Botany and zoology are not required courses except for majors and minors in these fields. Most students are required to elect a one-year course in a laboratory science. These sciences are botany, zoology, physics and chemistry. All students are required to take the one-quarter course in hygiene.

Most of the students considered have taken either a year or less of college botany or a year or less of college zoology. Only a limited number have taken both a year of botany and a year of zoology. Most of the students take their year or less of botany or zoology and their hygiene course the same year.

Conclusions

1. Those students having had high school biology have a slight advantage over the students having had no biology in making college grades. This is true for the students whether they take botany, zoology or hygiene. From the slight differences in the grades one might say that botany is the subject least frequently taught, zoology next, and hygiene most frequently taught in a so called high school biology course.
2. Those students having had ½ year botany and ½ year zoology showed an advantage over the no-biology students in botany, no advantage in zoology and actually did more poorly in hygiene. Their high school training gave them no advantage over the students having had no biology.
3. Those students having had one year of high school botany excel in college botany, college zoology and college hygiene.
4. The number for those having had high school zoology is small and not significant but it indicates too that the students tend to excell in college work.

5. The few students who have had both a year of botany and a year of zoology do superior work in their college courses. Apparently there is considerable transfer of training or information.
6. If these data are an index of conditions, then it is evident that those students who have had one year in a single subject course carry away with them from high school either more available factual material or a superior mental method of approach or both in the biological field.
7. Those students having had high school biology or ½ year of botany and ½ year of zoology have little advantage over those having had no biology. Apparently they retain from their high school training only a small amount of factual material or a poor mental method in biology or both.
8. Training for a year in high school in a one-subject course gives the student a better approach to further work in the same or related biological subjects in college, than a year of work in high school that attempts to cover the whole biological field.

The table below shows concisely the data considered.

COLLEGE GRADES IN THE BIOLOGICAL SCIENCES AS RELATED TO SECONDARY SCHOOL TRAINING

High school training	High school grade	Grade first college course taken	College grades first year or less	Difference between H. S. and college grades	Students considered	Per cent of college grades A's and B's	Per cent of college grades D's and F's	Average of raw psychological score
FOR STUDENTS TAKING BOTANY								
1. Biology 1 year	2.07	1.09	1.10	—.97	122	38	26	153.0
2. No biology		.96	1.03		150	34.2	31	163
3. ½ year botany, ½ year zoology	1.87	1.14	1.14	—.73	125	36.2	26	153.6
4. Botany 1 year	1.68	1.54	1.52	—.16	44	52.7	16	175
5. Zoology 1 year	2.14	1.00	1.13	—1.01	7	31.2	31	186
6. Two years: 1 year botany, 1 year zoology	2.12	2.62	2.47	—.35	8	94	0	150
FOR STUDENTS TAKING ZOOLOGY								
1. Biology 1 year	2.00	1.39	1.44	—.56	102	45.5	12	146.4
2. No biology		1.44	1.36		106	46.5	17	167.7
3. ½ year botany, ½ year zoology	1.71	1.30	1.35	—.36	109	45.6	18	157.7
4. Botany 1 year	1.57	1.74	1.53	—.04	35	49.3	8	162
5. Zoology 1 year	2.50	2.00	2.25	—.25	2	75	0	209
6. Two years: 1 year botany, 1 year zoology	2.50	2.00	2.28	—.22	6	92	0	151
FOR STUDENTS TAKING HYGIENE								
1. Biology 1 year	1.92	1.34		—.58	185	43.8	15	155
2. No biology		1.24			226	37.6	18	169
3. ½ year botany, ½ year zoology	1.81	1.17		—.64	189	37.6	21	161
4. Botany 1 year	1.57	1.47		—.10	75	48	11	164
5. Zoology 1 year	1.57	1.71		—.14	14	64	0	175
6. Two years: 1 year botany, 1 year zoology	2.37	2.00		—.37	8	88	12	150

NOTE.—Grade points given on basis of A=3, B=2, C=1, D=0, and F= —1. Students considered 882. 26.5% had H. S. Biology, 31.5% had NO Biology, 27% had ½ year Botany and ½ year Zoology, 11.4% had H. S. Botany, 1.8% had H. S. Zoology and 1.8% had both (1 year of Botany and 1 year of Zoology). Grades from the Eastern Illinois State Teachers College, Charleston, Illinois.

PAPERS IN CHEMISTRY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Chemistry Section carried twenty-one papers, of which fourteen are herewith printed. The others were:

The Importance of the Elements of the Rare Earths Group as Subject Matter in High School Chemistry, by A. E. Cockrum, West Chicago Community High School, West Chicago.

The Economic Importance of Clays as Ores of Aluminum, by F. M. McClenahan, Monmouth College, Monmouth.

Relation Between Chemistry and Bacteriology, by Verne E. Vinson, Commercial Solvents Corporation, Peoria.

Challenging Personalities, by Mable Spencer, Granite City Community High School, Granite City.

Apparatus for Showing Relative Amounts of Co_2 in Air and from the Lungs, by J. H. Ransom, James Millikin University, Decatur.

Experiments That Stimulate High School Students Interested in Chemistry, by Willard L. Muehl, Sterling Morton High School and Junior College, Cicero.

Methane in Illinois Ground Waters, by T. E. Larsen, Illinois State Water Survey, Urbana.

Average attendance was about 50 in each of the two sections.

Dr. John DeVries, Knox College, Galesburg, Illinois, was elected Chairman for the 1939 meeting.

(Signed) G. W. THIESSEN, *Chairman.*

Audio-Visual Aids in Chemistry at the Secondary Level

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I. Introduction

Of necessity, I shall limit the subject, "Audio-Visual Aids in Chemistry at the Secondary Level," to certain aspects of the problem specifically concerned with the selection and use of such aids. Any statement, however general, may well illuminate some of the pupil-teacher problems in relation to such materials of instruction. Beyond these considerations, some emphasis will be placed on the selection and use of two groups of aids: (1) radio programs, including electrical transcriptions, and (2) slides, filmslides, and films, both silent and sound.

II. Pupil-Teacher Problems

Mr. Douglas E. Lawson, of this University, in speaking on the "Changing Concepts of the Mind,"[1] has summarized in an admirable way the basic pupil-teacher relationships for all learning when he says for the teachers:

> "We attempt to change stimuli, to direct processes, to establish conditions."

He then summarizes his thinking on the subject by saying:

> "We guide, direct, motivate."

Guiding, directing, and motivating students is the indispensable role of the teacher, regardless of whether the subject is chemistry or Latin; of whether the medium is the latest sound film or the most traditional of texts. In relating guidance, direction, and motivation to audio-visual aids the effective teacher will utilize the fundamental principle of pupil participation. Group activity, as an aspect of such participation, will be used also for maximum values. [It may have been such a conception which led Donald A. Laird, the psychologist to say:

> "Belonging to and working with a group changes each active individual, strengthens his ordinary emotions, and propels him further toward the goal of the group than he could ever push himself without the miracle wrought by the mere fact of *belonging*."]

Concerning the teacher in relation to the effective use of audio-visual aids, we may be led to say in moments of idealistic reaction that real teachers do not need such materials. We are apt to point with pride to the increased teacher training requirements, without pausing to examine the net results. Under such circumstances, we may be genuinely disturbed by Alstetter's report[2] for the Cooperative Study of Secondary School Standards—operating under the American Council of Education. His survey places science teachers, whose major teaching field is science, fifth in the teacher groups of secondary schools from the standpoint of semester hours earned in training for the respective teaching field. That is to say: foreign language teachers rank first with an average offering of 33.6 hours in foreign languages; social studies teachers have 31.2 hours; English teachers, 23.4 hours; mathematics teachers, 21 hours; and science teachers, 19.8 hours. Even if we were to assume that in Illinois, the average chemistry teacher had training equal to that of the foreign language teacher; that is, 33.6 hours, we would still be forced to recognize the fact that much of the average chemistry teacher's training has suffered for lack of recency and

that much of the original training was not specifically directed toward the needs of the chemistry courses of the secondary school as they now are and as they are coming to be. The point I am getting at is this: Much is being said and rightly so, it seems to me, about in-service training in the use of audio-visual aids. Little has been said about audio-visual aids, such as the sound films I am to present for the first time in this section of the State (if not in greater area) as in-service training material for teachers. In-service training material for the under-trained, under-paid, and over-worked classroom teachers represents one of the practical approaches to the problem of better teaching. . . . The unseen lecturer of the film, based on inherently silent material, may be eliminated in favor of the teacher's voice as soon as he feels competent to make the presentation. In the same way, capable students may supplant the teacher in repeated showings.

Regardless of the contributions which have been made for audio-visual aids through the science of chemistry, the need of special training courses for chemistry teachers at the secondary level, with reference to such aids, is probably about as pressing as for any other group of teachers at that level. This point is worth making in view of the fact that there were but three training schools in Illinois which offered summer session courses in audio-visual aids last summer. This record was only exceeded by Pennsylvania where this course is required of all prospective teachers and is offered in all teacher-training institutions of that State. Thus, forty-four of the eighty-six schools offering summer session courses were to be found in one state. Obviously, the eighty-six courses considered together are inadequate for the 850,000 teachers of the United States. The sooner teachers of chemistry, and of other subjects, have had sufficient training to select and use audio-visual aids effectively, the sooner we may expect desirable improvements in the content of such media. That is to say, master teachers themselves should constitute one of the important tribunals concerned with the audio-visual needs of the classroom. The State Academies of Science, the American Chemical Society, and similar bodies through national and state committees[3], may well render positive approvals for specific films and other teaching aids. Likewise, these organizations through concerted action may render a distinct service to education by indicating the materials of greatest need.

III. The Radio Program

The teacher using the radio program in the classroom finds himself beset with many problems. While class periods based on the whole clock hour appear to be increasingly more common, many secondary schools are still operating on periods of forty-five minutes with double periods for laboratory courses. This is further complicated by daylight saving time in given areas; by school days beginning at different hours; by assembly periods of variable lengths substituted for given class periods; by "home room" and "activity" periods of lengths varying with the individual schools and sandwiched in the school day at no common point; and, also, by situations wherein the regular class periods—due to the shortage of rooms and other factors—run through the noon hour. And further, is the fact that given academic subjects are offered at different hours in different schools; perhaps at all hours of the school day in the larger schools. The resulting picture becomes a pattern of variability equally disconcerting to the classroom teacher trying to use the programs and to the administrators who are in sympathy with such usage but are unable to do much about it. I have presented this analysis in order that the problem of obtaining radio service for a given class might be seen in relation to a scheduled series of radio programs. Of course, such series of programs to be effective must be presented at a fixed time in the day as well as in the calendar and on the dial.

We are fortunate, indeed, in having one of the thirty-odd educational radio stations in our state. With the increased power by which all schools in the state may be reached, it occurs to me that there is a further significant problem for such educational stations as WILL, and that is the opportunity to use the evening hours for educational service. Again, such

a valuable service in the cause of education can only come about through the united action of educational forces actually demonstrating selection and use of educational radio programs. For five consecutive years, Station WILL had made possible the broadcasting of the weekly programs of the Illinois Junior Academy of Science. These programs were designed for science club members and as much constituted an aspect of extra-class activities. Students freed from the barriers of the official school day have been free to listen and to participate in these programs. If more time could be made available after school hours, much more could be done through such stations to enrich and to support the curricular offerings. As I have said on a previous occasion,

> "I believe that we may yet produce an educational system wherein the needs, interests, and abilities of the child, rather than the minutes of the hour, will serve more fully as a criterion for what the child is to be doing throughout the school day."[4]

It was with such a point of view in mind that Joy Elmer Morgan, Editor of the Journal of the National Education Association once said of the radio:

> "If it can add as much as five percent to the effectivness of our schools—and that is a most conservative estimate—it is worth $100,000,000 a year to the educational enterprises of our various states and communities."[5]

Assuredly, it is no mythical idea that we may have the recreated voices of Madam Curie, of Charles Martin, of Albert P. Mathews, and of our own B. S. Hopkins, speaking as we need them to inspire our students in behalf of chemistry as it could be done in no other way. Through the medium of the electrical transcription we may continue to dwell in the presence of these enthusiastic masters of chemistry. Only the concerted demand of chemistry teachers is required to make possible a library of such vital records for students of the future. Such a library in a greater or lesser degree can likewise become the property of the average school, as can visual complements in the form of film-slides, biblio-films, lantern slides and other materials.

IV. Recent Developments Implying Correlation

These suggestions are not theoretical ones. To illustrate: "Radiovision" is the term used to designate the weekly educational radio programs called, "The World is Yours."[6] Specially prepared filmslides will be developed and distributed by Mr. Gustave Marx in cooperation with the Smithsonian Institute, the National Office of Education, and the National Broadcasting Company. This project is intended to benefit schools and other interested agencies.

The biblio-film or micro-film idea has been developed under the direction of Watson Davis of Science Service, in cooperation with the Chemical Foundation and other scientific organizations. These biblio-films are made on 35 mm. motion picture stock and represent 1,600 pages of text or manuscript. Special projectors are used to magnify the material to at least the size of the original page.[7]

Again, the rotoprint process,[8] of producing diagrams, sketches, pictographs, and graphs on transparent transolene at a cost of 12 cents per lantern slide, in quantity production, represents a development which should lead to a wider use of the standard stereoptican.

From many angles, it is apparent that no one type of audio-visual aid is adequate for all types of desirable and practical learning situations. Further, there is an increasing recognition of the idea that the various types of aids must be correlated with each other as well as with the subject matter. One of the types of audio-visual aids in which sound and pictorial values are closely if not perfectly correlated is the sound film. Obviously, there is no quality inherent in the sound film which will insure that the material will always be perfectly selected and perfectly presented. Indeed, I have seen sound films that might as well have been produced

in silent form at approximately half the cost. Likewise, I have seen silent films that might as well have been produced in the form of lantern slides, but for the fact that some schools now possess a motion picture projector and no longer have a stereoptican in working order or otherwise. Again, I have seen as all of you have, motion pictures that failed or succeeded because color was wanting or was present. Too few of the educational sound films present facts in such a way as to build up a problematical situation from which solutions requiring deductive and reflective thinking are required. In the matter of selection and use of these aids, we should keep in mind the extent to which motion, sound, and color are inherent and indispensable qualities of the subject. These considerations tend to be underemphasized in the literature and in the evaluation schemes such as those of Brunstetter,[9] and Lemler,[10] nevertheless, they may be vital when measured in terms of desirable student responses.

If the classroom work is to be improved materially through audio-visual aids, the attention of every teacher using them must be focused constantly on the important problems of selection and usage.

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Modernizing the Beginning Course in Chemistry

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We live in a day when modernizing is quite the rage in most activities of life. It is especially important that the subject matter of all our school courses be overhauled frequently. Many of us remember the shock we received when we first found out that the Santa Claus hypothesis was just a childish myth and must be superseded by a new theory more in keeping with the facts. It seems unreasonable to teach in the name of simplification some half truth or outright falsehood which will have to be unlearned later. It has been my experience that the true explanation is usually more easily understood than the so-called simpler outmoded one. The first principle, then, in modernizing a course is to remove from it any statements which will not bear the test of modern knowledge. Some instructors, for example, believe it is right to teach the classical ionization theory to beginners and to teach the modern 100% ionization for strong electrolytes to advanced classes. This results in confusion which could have been avoided since the modern theory is more easily grasped anyway and explains the facts much more fully.

There are dozens of other places where a similar situation is found, a few of these being: valence, oxidation-reduction, acid-base definitions, etc.

Statements are frequently made that the subject matter of chemistry may be given in any order with due allowance for introductory explanation. Perhaps it is partly true, because chemistry in some ways may be compared to a circle in which one may start almost anywhere and fill in until the circle is complete. However, there is a natural order which appeals to me as reasonable. Chemistry deals with matter. Matter is composed of protons, neutrons, electrons, deutrons, alpha particles and what not. Here is a logical place to bring in this matter of ultimate particles instead of in the middle of the year or later as many books do. Furthermore, this information should be used and not just dragged in and then ignored for the older explanations.

Following this, the simpler aspects of atomic structure should be taught, bringing out the importance of the atomic number which leads to the discussion of the Periodic Chart. This latter can not be gone over in detail because the students are not familiar enough with the elements. Nevertheless they can be taught the principles of the groupings of the chart and its uses. After this the chart should be constantly used by the instructor and all possible facts pigeon-holed in it.

In atomic structure, aside from the atomic number, the number of valence electrons is probably the most important factor. The latter should also be stressed as a background for chemical combination and the study of valence.

Following the traditional method, I formerly found the concept of chemical union an extremely difficult one to explain. How is a mixture of 39 parts of potassium and 127 parts of iodine different from potassium iodide? The orthodox answer is that in potassium iodide the atoms are chemically united. But what meaning does this term have? By introducing the concept of electrons, it is very easy to show that in the mixture each atom has its full quota of electrons but in KI an electron originally belonging to the potassium has been taken over by the iodine. This gives the potassium a positive charge since it has lost one negative particle, and the iodine becomes negative since it has an excess of one negative particle. The two charged atoms called ions are mutually attracted to each other and arrange

themselves in a definite crystal lattice. In the case of homopolar or covalent compounds the electrons instead of being transferred are shared and so the two elements are held together. In case this seems to be too much of atomic theory, one could just mention that part of the actual substance in the outer part of the atom (which is known to consist of electrons) is transferred to another atom causing the union.

This explanation has something to it, is true and not beyond the understanding of the beginner. Given this information, the student should be called upon to use it frequently. Hazlehurst[1] has pointed out the exact inconsistency in our teaching where we drag in these newer concepts as more or less extraneous curiosities and then fail to make use of them in any real way. As a matter of fact the material just considered is fundamental to chemistry and not just interesting oddities. Hazlehurst also points out another difficulty when we use the word "abnormal" to describe the behavior of electrolytes as to colligative properties. The beginner studies many more electrolytes than he does "normal" solutes. Strictly speaking they are not abnormal since an ion in a salt such as NaCl has practically as much independence as a molecule of sugar and so one should expect it to have a comparable effect on the freezing point lowering and similar phenomena. Moreover the ions in NaCl are charged and so when free to move due to solution in a suitable solvent or after melting they can carry a current, which the particles (molecules) of sugar for example can not do since they are uncharged.

The study of such material as atomic weights, molecular weights, valence, compounds elements, mixtures, chemical and physical change, should be used whenever it fits in with the concepts mentioned above. The study of oxygen, hydrogen, and water, which usually come near the first part of the course, may profitably wait until at least the most of this background material is completed. It will be at once noted that laboratory work suitable to accompany the introductory material will be difficult to find. I have a strong suspicion that that is why oxygen is introduced so early in most courses. With suitable arrangements, the laboratory time may be used for discussion, lectures, and demonstrations as well as suitable movies until a point is reached where laboratory work will fit in. No doubt a complete revamping of the laboratory work is in order anyway. I am one of the many who are unwilling to substitute demonstrations for individual laboratory work, but some change is in order. The newer laboratory manuals are stressing motivation. If some series of laboratory experiments could be derived where there is the element of the unknown as in the case of qualitative analysis, instructors would find the students as industrious there as in the latter.

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Laboratory Experiments for an Introductory Course in Organic Chemistry

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The chief objective in an introductory course of organic chemistry is the selection of pertinent facts and the arrangement of these in such a manner as to develop and illustrate the fundamental principles of the carbon compounds. The laboratory work in most courses consists largely of experiments in which the sole object is to attempt one preparation after another. In a previous paper[1], a series of experiments was described to show both general group properties and reactions as well as difference in reactivity. The paper is a further elaboration of such a laboratory course. The plan followed is the arrangement of the compounds of carbon into groups which show related properties. The usual separation into aliphatic and aromatic compounds is avoided. For instance, in the monohalogen compounds, if we write R-X, where X is a halogen, for the general formula of the organic monohalide, it is possible to treat first all reactions which are common to the monohalides and then to show how the radical R influences the rate of reaction of the compound. The experiments on two units are described in this paper: hydrocarbons and the monohalides.

Experiments on Hydrocarbons: The preparation of n-butane by the use of the Grignard reagent illustrates the reduction of a monohalide to the hydrocarbon and introduces the student to a simple reaction which later will be found applicable to the preparation of other groups of organic compounds. The preparation of n-butyl magnesium bromide is made according to standard method[2], using 0.1 moles of the reagent. The hydrocarbon is generated by the addition of water to the Grignard reagent and collected by water displacement after passing the gas through an empty bottle immersed in an ice mixture, then through sulfuric acid. The usual tests on combustibility, action of bromine and potassium permanganate are made on the samples collected. The experiment can be used as demonstration.

The Wurtz-Fittig reaction[3] illustrates the preparation of a hydrocarbon by the union of two radicals when two monohalogens are reduced under anhydrous conditions. Ethyl benzene is prepared using 20 g. of bromobenzene, 17.3 of ethyl bromide, 40 cc. of dry ether and 9 g. of sodium. Yields of 45-65% are obtained by the students.

Methane and benzene are prepared by test tube experiments which illustrate the removal of the carboxyl group. Five grams of sodium acetate or sodium benzoate are heated with two grams of soda lime in an ignition tube. The unsaturated hydrocarbons are introduced by means of amylene and cyclohexene. The former is easily prepared by the careful dropwise addition of 2 cc. of sulfuric acid to 5 cc. of ter-amyl alcohol well cooled. Cyclohexene is prepared by distilling a mixture of 50 cc. of cyclohexanol with 8 cc. of sulfuric acid. This is followed by a brief study of the properties of acetylene and benzene.

The unit is closed with a study and contrast of reaction properties of several hydrocarbons from each group. Ten drops of each of the following hydrocarbons are used in each test: pentane, isopentane, pentene, hexane, cyclohexane, cyclohexene, cyclohexadiene, benzene, toluene and naphthalene. The reaction of these towards of the following reagents is studied: neutral or alkaline 0.04% potassium permanganate, 2% bromine solution in carbon tetrachloride, concentrated nitric acid, and concentrated sulfuric acid. These

experiments illustrate the rapid reaction of the unsaturated, the relative inertness of the saturated and the relation of benzene to the other six-carbon cyclic hydrocarbons. The reactions of cyclohexene and cyclohexadiene with bromine and pottasium permanganate are instantaneous, and explosive with nitric and sulfuric acids. Yet benzene (cyclohexatriene) exhibits a stability characteristic of the saturated structures. Later, the various theories to account for this stability are presented.

Experiments on Monohalides: In this unit which follows that of hydrocarbons a number of experiments are used to illustrate the general methods of preparation and characteristic reactions of the monohalogens. The preparation of the alkyl halides by the reaction of the monohydroxy alcohols with aqueous hydrogen halides[4] is easily illustrated by mixing 5 cc. of the three butanols with 10 cc. of concentrated hydrochloric acid. The tertiary chloride separates out immediately while the secondary and primary require addition of zinc chloride and heating. The preparation is related to the application of the law of mass action to: $R\text{–}OH + HX \rightleftharpoons R\text{–}X + HOH$.

The formation of halides by the direct halogenation of the hydrocarbons is illustrated by a demonstration of bromination of benzene. Halogenation of hydrocarbons in general is discussed, including the use of catalysts, methods of introducing the chlorine or bromine and products formed. The preparation of n-butyl bromide using the sodium bromide method[6] is performed by the student with the main objective of obtaining a good yield. This is followed by a series of tests designed to illustrate a number of general reactions such as hydrolysis, ammonolysis, removal of halogen acid, etc. It is also possible to show differences in the reactivities of the various groups of halides. The tests on hydrolysis of n-butyl, sec-butyl, ter-butyl, n-amyl, cyclohexyl, phenyl, benzyl and naphthyl chlorides has been described[6]. The ammonolysis of monohalides is illustrated by the action of 1 g. of methyl iodide, n-amyl bromide and ter-amyl bromide with 5 cc. of saturated solution of ammonia in 90% methanol. Methyl iodide forms mostly quaternary salt; n-amyl a mixture of amines, and ter-amyl mostly olefins. The action of alcoholic potassium hydroxide on: n-amyl, ter-amyl, cyclohexyl, phenyl and benzyl chlorides illustrates the condition for olefin formation as well as differences in the relative stability of the halides.

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The Ammonolysis of Butyl Halides

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The study of the ammonolysis of the butyl halides is part of a general investigation on the ammonolysis of halogen compounds.

The reaction of an alkyl halide with aqueous ammonia involves formation of amines, alcohols, olefins and ethers, depending on the nature of halide and conditions under which the reaction takes place.

The rate of reaction is determined fairly accurately by analysis for a halide ion by standard methods. A modification must be made in the case of ter-butyl halides as they react rather rapidly with silver nitrate. The sample in such cases is rapidly evaporated under reduced pressure until ammonia, solvent and unreacted halide have been removed.

A new method was developed for the estimation of primary amines. Briefly, as applied to the butyl amines, it is as follows: The sample, made strongly alkaline, is extracted with ether. The extract is shaken for one minute with specially prepared silver chloride and then for one minute with sodium cobaltinitrite. The ether extract is filtered, titrated with 1.0 N HCl and the ether evaporated. The residue is made to standard volume. The primary amine is determined by the micro-Van Slyke method, while the secondary and tertiary are determined by a modification of Weber and Wilson's method.*

Table 1 shows the rates of ammonolysis of the four butyl bromides in alcoholic-aqueous ammonia at 25°C. Table II shows the composition of the final equilibrium mixture. Table III, the effect of various concentrations of ammonia on the amounts of various amines formed, and Table IV, the rate of ammonolysis of n-butyl bromide in aqueous ammonia at 60 and 100°C.

These results seem to indicate that higher conversion to amines takes place in the straight chain halides; the tertiary reacts rapidly, but less than ten per cent is converted to amine with olefin formation assuming a dominant role. Increase in the ratio of ammonia to the halide increases the amount of primary amine. Using four moles of ammonia to one of n-bromide, the formation of primary amine is rapid up to the half point of the reaction, then drops as the secondary and tertiary amines are formed at a more rapid rate than before. The relative amounts of the three amines are not greatly affected by increase in temperature.

Ammonolysis in aqueous system takes place at the interface of the halide and aqueous layers; it is slow at 60°C. but fairly rapid at 100°C. The composition of the final equilibrium mixture is not appreciably different for aqueous or alcoholic (90 per cent alcohol) ammonia systems. Catalysts such as copper and other metals do not have any effect at temperatures of 100°C., while substances which increase the surface by dispersion of the immiscible halide accelerate the reaction.

SUMMARY

1. The rate of ammonolysis of the four butyl bromides was measured at 25° and 60°C. with alcoholic ammonia.
2. The ammonolysis of n-butyl chloride with aqueous ammonia was measured at 60° and 100°C.
3. The influence of temperature and ammonia concentration on the equilibrium mixtures was determined.

* Journ. of Am. Biol. Chem., 35:385 (1918).

TABLE I—RATES OF AMMONOLYSIS OF BUTYL BROMIDES WITH ALCOHOLIC AMMONIA* AT 25° C.

Bromide	Time required for conversion of 0.5 mole of bromide	Reactivity	Total conversion to amines	Per cent conversion to amines
	Hours		Moles	
ter-Butyl	2.0	1,000	0.07	14.0%
n-Butyl	14.5	138	0.50	100.0%
sec-Butyl	266.0	7.5	0.48	96.0%
iso-Butyl	480.0	4.1	0.40	80.0%

* 20% ammonia in 90% methanol.

TABLE II—AMMONOLYSIS OF BUTYL BROMIDES WITH ALCOHOLIC AMMONIA* AT 25° C.

COMPOSITION OF THE FINAL EQUILIBRIUM MIXTURE

Bromide	Time	Halide ion produced	Total conversion to amines	Per cent conversion to amines	$R\text{-}NH_2$ %	R_2NH %	R_3N %
	Hours	Moles	Moles				
Tertiary	12	1.00	0.085	8.5%	5.8	----------	----------
Normal	131	0.978	0.94	97.0%	32.4	41.6	20.3
Secondary	885	0.94	0.93	99.0%	76.0	9.0	8.4
iso-	885	0.875	0.716	81.9%	44.4	17.5	19.7

* 20% ammonia in 90% methanol.

TABLE III—AMMONOLYSIS OF N-BUTYL BROMIDE AT 25° C.

(Effect of Ammonia Concentration)

Ratio of $BuBr:NH_3$	Time	Temp. °C.	Halide ion production	Total conversion to amines	Per cent conversion to amines	RNH_2 %	R_2NH %	R_3N %
	Hours		Moles	Moles				
1:4	313	25	0.978	0.94	97.0	32.4	41.6	20.3
1:8	100	25	0.970	0.97	100.0	53.0	12.4	31.6
1:60	80	25	1.00	0.997	99.7	82.5	11.4	5.8
1:4	6	60	0.995	0.995	100.0	43.0	44.2	12.3

TABLE IV—AMMONOLYSIS OF N-BUTYL CHLORIDE WITH AQUEOUS AMMONIA AT 60° AND 100° C.

(Ratio of Halide to Ammonia 1:4)

Run number	Moles of halide	Diameter of ampule	Temp. °C.	Time hours	Halide ion produced %	Amine produced total %	RNH_2 %	R_2NH %	R_3N %
655	0.01	16	60	60	31.4	------	------	------	------
656	0.02	16	60	83	16.4	------	------	------	------
657	0.01	21	60	83	38.1	------	------	------	------
661*	0.01	16	60	83	49.1	------	------	------	------
783†	0.01	16	60	83	72.4	------	------	------	------
630	0.02	21	60	151	50.1	47.6	25.1	12.0	10.5
631	0.02	21	60	384	88.7	84.0	38.8	20.6	24.6
632	0.02	21	100	48	99.5	84.2	39.2	23.4	21.6
660‡	0.02	21	100	6	.993	89.6	38.4	29.6	21.5

* Clay, 83 mg. added.
† Bentonite, 83 mg. added.
‡ With 4 moles alcoholic ammonia.

Four Years of the Physical Science Survey Course—An Appraisal

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AN ABSTRACT

During the summer of 1934, the three municipal junior colleges of Chicago were established with a primary objective of "developing in all students social intelligence, responsibility, and personal culture by means of a well-organized program of general education", and with secondary objectives of supplying pre-professional or semi-professional training for such students as desired it. In order to accomplish the first aim, the curriculum requires all students to take five survey courses, occupying about half of their time, with the other half devoted to courses in the fields of the student's major interest.

One of these survey courses is in physical science, which covers the fields of physics, chemistry, astronomy, and geology, with especial emphasis on the first two. The aims of this course are:

To make the student more familiar with his physical environment;

To give the student an appreciation of the scientific method;

To develop a point of view and a philosophy concerning natural phenomena; and

To lay the foundation for possible future work in the Physical Sciences.

In organizing the course, these objectives were interpreted as implying primary emphasis on the development of understanding and appreciation of the principles of science rather than of its technological aspects. The course is presented by the lecture-demonstration method to large groups (in some cases slightly over 300), in three lectures and one quiz period a week. A syllabus was developed by a committee of the three colleges and put into the hands of the students. No single text-book has been adopted; the students are asked to purchase college chemistry and physics texts and to do a great deal of reading in the library.

Since that time some 5,000 students have taken the course at Wright Junior College. In practice it has by no means proved entirely satisfactory either to students or to the faculty. The subject matter has been revised several times, and is in process of radical revision at present. Such changes are based not only on the opinions of the instructors giving the course, but also to a considerable extent on the opinions of the students, who have been asked at the end of each semester to fill out questionnaires and to make suggestions. The general trend of the revisions has been in the direction of eliminating details and of concentrating attention on the relatively few principles which are felt to be of really paramount importance.

The present revision will be especially drastic for several reasons. In the first place, it is felt that certain of the objectives are not wisely chosen, in particular that of preparing students for future work in science. Secondly, those aims which are considered valid are too vaguely stated; interpretation in more specific terms is felt to be necessary. Detailed criteria for the selection of subject matter are being drawn up, and their application will, it is hoped, result in the elimination of more detail of little value to the student who is seeking general education. Third, it is believed that too little emphasis has been laid on the impact of science and invention upon society, and on the minor applications of science which recur again and again in the student's daily life.

The new course developed on these lines will of necessity be very different from the old. To find what the results of the application of these ideas will be is matter for experimentation; upon those results it will doubtless be necessary to rebuild the course again and again.

Some Concepts of the Relationship Between the Chemical Compositions and Structures of Clay Minerals*

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The common clay minerals which have been investigated up to the present time can be classified in one or the other of two general structural types. The first type may be thought of as resulting from the condensation of an hexagonal net of silica tetrahedra with a layer of hydrargillite giving rise to a double layer of composition $(OH)_4Al_2Si_2O_5$. The second type arises from the condensation of two such silica nets, one above and one below, with one hydrargillite layer, giving rise to a triple layer of composition $(OH)_2Al_2Si_4O_{10}$.

Of these two types the first seems to be the less variable. It includes kaolinite, nacrite, dickite, and the halloysites. The second type is subject to many significant variations in chemical composition with concomitant effects on physical properties. In this group are found montmorillonite, beidellite, nontronite, illite, and perhaps several others. It has been suggested by several investigators, notably Linus Pauling[1] and C. E. Marshall[2] that the broader chemical freedom of the second type is due to the greater stability of its symmetrical configuration. It is with the inferential relationships between the chemical composition and properties of the second type that this paper is concerned.

In these two idealized types, each silicon ion is located in the interstice between four oxygen ions in tetrahedral configuration, and each aluminum ion in the interstice between six oxygen (or hydroxyl) ions in octahedral configuration. On the basis of various proven structures for silicate minerals, the following substitutions have been suggested as possible: tetrahedral positions may be occupied by Al^{+++} or by P^{+++++}; octahedral positions may be occupied by Mg^{++}, Fe^{++} Fe^{+++}, Ti^{++++}, or Li^{+}.

By far the most common, the best authenticated replacement, is that of Al^{+++} for Si^{++++}, as it occurs in muscovite.[3] One fourth of the Si^{++++} positions are occupied by Al^{+++}, and the excess (—) charge resulting is compensated by the presence of one K^{+} ion in 12-coordination between triple layers. Muscovite builds a rigid stable crystal with perfect cleavage between layers. Its rigidity is attributed to the attractive power of the K^{+} ions for each of the adjacent triple layers. Illite, perhaps the most widely distributed clay mineral in Illinois, exhibits the same crystal structure as does muscovite. It differs in having a lower K_2O content, a higher relative content of SiO_2, and in the exhibition of moderate base exchange properties. Whereas the ratio of Si^{++++} to Al^{+++} in the tetrahedral layers for muscovite is 3, and one K^{+} ion is required for each set of 4 such positions, the similar ratio for illite may be 6 or 7 or higher, and only about one K^{+} ion is required for two sets of 4 such positions. Thus the illite, being subject to only about one-half the attractive forces responsible for the crystal habit of muscovite, occurs as a clay rather than as macro-crystals. The analogy between the two minerals is perhaps better illustrated by examination of "structural formulae" for each:

Muscovite $(KAlSi_3)\ Al_2\ (OH)_2O_{10}$

Illite $(K_xAl_xSi_{4-x})\ (Al_2 \cdot Fe_2 \cdot Mg_3 \cdot Mg_2)\ (OH)_2O_{10}$

where $x < 1$, usually about $\frac{1}{2}$.

A second common, and significant, replacement is that of Mg^{++} (or Fe^{++}) for Al^{+++} in octahedral positions. This replacement, presumably can occur in either of two ways, as has been implied in the above formula.

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Three Mg^{++} ions may perform the role of two Al^{+++} ions as has been deduced in the case of several biotite micas, and of talc, without the introduction of any unbalanced charges, or one Mg^{++} ion may directly replace one Al^{+++} ion with the appearance of one excess (—) charge per replacement. Such a (—) charge, however, differs from that observed in the case of muscovite in that, whereas, the muscovite charge is localized at the surface of a unit and can be readily balanced by an adjacent K^{+} ion, this second sort occurs in the middle of a stable structural unit. Observations on specimens of montmorillonite have shown that the number of this sort of charges approximates the base exchange capacity. Montmorillonite is a soft, finely crystalline, and very readily dispersed clay with high base exchange capacity.

Nontronite is a name applied to several clays with physical characteristics quite similar to those of montmorillonite, but with more or less Fe_2O_3 content. These are presumed to arise from substitution of Fe^{+++} ion for Al^{+++} ion in octahedral positions, a substitution which does not effect electrical neutrality. Both nontronite and another similar clay, beidellite, are commonly distinguished from montmorillonite on the basis of lower $SiO_2:R_2O_3$ ratios, but neither is fully characterized at present.

No natural clay has yet been observed where only one sort of replacement could be shown to be active. However, these qualitative considerations of the relations between physical properties, structure, and chemical composition lead to the suggestions that in cases where the first sort of substitution predominates one finds the illites, with stable lattice dimensions, moderate plasticity, and moderate base exchange capacities; where the second sort of substitution predominates the clays swell on addition of water, disperse readily to extremely small particle sizes, and exhibit high base exchange capacities.

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The Mono-Nitration of Benzotrifluoride*

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Benzotrifluoride ($C_6H_5CF_3$) and its derivatives show promise of becoming commercially significant, due to their unusual properties. The $—CF_3$ side chain, in contrast to its chlorine analog, $—CCl_3$, is remarkably stable to most chemical reagents. Benzotrifluoride is readily prepared from benzotrichloride and anhydrous antimony trifluoride, usually with heat and pressure.[1]

The most common approach to the synthesis of benzotrifluoride derivatives is through the meta nitro compound and is illustrated by the following equation:

$$C_6H_5CF_3 + HNO_3 \rightarrow CF_3 \cdot C_6H_4 \cdot NO_2\ (1,3) + H_2O$$

Swarts,[2] in 1898, obtained a 89 per cent yield by nitrating benzotrifluoride with a large excess (approximately 500 per cent) of fuming nitric acid. The reaction was run at 0°C and then finished off at reflux temperature. Aelony[3] reported a yield of 89.5 per cent using the same method. Booth[4] modified the procedure slightly and reported a 96 per cent yield with a mixture of one part of fuming nitric (sp. gr. 1.5) acid and 1.5 parts of concentrated sulfuric acid. The latter procedure is very indefinite, as no supplementary information was given to clarify it; the high yield may have been based on the crude product. The status of this nitration obviously is (1) that fuming nitric acid is used in large excess, (2) the addition of sulfuric acid increases the yield, (3) the nitro compound is very stable, and (4) the high yields indicate the absence of higher nitration products. Swarts,[4] in a very careful study, also showed that 99 per cent of the nitration was the meta derivative, which shows that the $—CF_3$ group is one of most powerful meta directing groups known.

With the above facts in mind, a study was made to determine the factors which influence the yield, so as to evolve a more simple and economical procedure. The experiments were divided into classes, (1) nitration by a nitric acid—sulfuric acid mixture, and (2) nitration by solid sodium nitrate in the presence of sulfuric acid. The factors of temperature, concentration of reagents, relative amounts of reactants, and time were studied.

Experimental

The nitrations were run on 0.5 or 1.0 mol quantities of benzotrifluoride (b.p. 99-100°C.) in a 500 cc. three-necked flask, equipped with a mercury-sealed or a closely fitted shaft stirrer, a thermometer, and, in the case of the nitric acid method, a separatory funnel. The concentrated sulfuric acid was the ordinary c.p. acid (95.5-97 per cent). Agitation was vigorous enough in all cases to obtain intimate contact of all reactants. At the end, the nitration mixture was poured over ice; the crude nitro compound separated as a heavy pale yellow to cream colored oil. The oil was washed once again with water, then twice with approximately two per cent sodium carbonate or sodium hydroxide solution, giving a yellow to orange aqueous layer, and finally with water. The washings were all extracted with ether and the combined ether extracts treated in the same way as was the crude nitro product. The crude product and ether extracts were separately dried over anhydrous magnesium sulfate.

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The magnesium sulfate was removed by suction filtration. The dried ether extracts were evaporated on a steam cone and the residue was then combined with the main fraction. All distillations were made by using a Claisen flask-air condenser set up with an oil bath for heating; the pure fraction was taken at 200-203°C.

The material which remained after removal of the main fraction from all experiments was combined. Vacuum distillation of this residue showed that it consisted almost entirely of the mono nitro compound. Therefore, the yields may actually be somewhat higher than listed.

a. Nitric acid-sulfuric acid mixture

The literature, as well as preliminary work, appears to indicate that the addition of concentrated sulfuric acid to the nitric acid favors an increased yield; consequently all of the experiments were made with a nitric acid-sulfuric acid mixture. Since only a mononitrate can be formed, the benzotrifluoride was added dropwise to the nitric-sulfuric acid mixture with occasional cooling to hold the temperature between 30 to 35°C. The experiments are tabulated in Table I.

TABLE I—YIELDS OF $CF_3.C_6H_4.NO_2$ 1,3

(Nitric acid-Sulfuric acid Method)

Sp. Gr. HNO_3	Per cent excess HNO_3	Moles of H_2SO_4	Mol ratio $\frac{H_2O‡}{H_2SO_4}$	Yield of $CF_3.C_6H_4.NO_2$ (1,3) in grams			
				Theor.	Crude	Pure	% (Pure)
1.42–1.425	10	0.75	2.05	95.5	78.3	40.3	42.2
1.42–1.425	10	1.05	1.5	95.5	90.0	73.8	77.2
1.42–1.425	10	1.23	1.25	95.5	92.5	82.9	86.7
1.42–1.425	10	1.55	1.1	95.5	93.1	86.8	90.8
1.42–1.425	10	2.25	0.85	95.5	90.3	84.3	88.3
1.42–1.425*	10	2.25	0.85	95.5	92.8	85.5	89.5
1.42–1.425	10	5.36	0.5	95.5	92.4	81.4	85.2
1.42–1.425	100	4.17	..92	95.5	90.3	85.3	89.2
1.49–1.5	568	3.14	.57	95.5	90.4	73.9	77.2
1.49–1.5*†	568	6.28	.57	191	176	166.8	87.3
1.59–1.6*†	602	6.4	.38	191	180	164.5	86.2

* Nitration at 30-35° throughout; all others finished off at 60°.
† One mol of $C_6H_5CF_3$ used; all others based on 0.5 mol quantities.
‡ Total water at the end of the nitration.

The yield of nitro compound is almost entirely independent of amount or specific gravity of the nitric acid above certain limits. The amount of sulfuric acid is the most important factor and the optimum condition is approached when the mol ratio of water to sulfuric acid is one. This includes the water present in the original reagents plus the water theoretically formed in the reaction. High concentrations of sulfuric acid cause a decrease in the yield, probably due to sulfonation. Preliminary experiments indicated that a nitration temperature of 0°C. was of no yield advantage and involved a great loss of time and an increased cooling cost. On the other hand, a temperature around 30-35° was very convenient to control and the reaction was finished off at 60°C. Raising the temperature after all of the benzotrifluoride had been added cut the total reaction time down from about 2½ hours to one hour.

In summary, the optimum conditions involve (1) a 10 per cent excess of concentrated nitric acid, (2) sufficient amount of concentrated sulfuric acid to form a monohydrate with the final total water content, (3) and a temperature of 30-35° for nitration with a finishing off at 60°C. Ninety per cent yields of a pure product are obtained under these conditions.

b. Sodium nitrate-sulfuric acid mixture

Commercially, many nitrations are made by adding solid sodium nitrate to a mixture of sulfuric acid and the compound to be nitrated. Sodium nitrate is not only much lower in cost than nitric acid but the equipment overhead is also much less. This method with benzotrifluoride can be illustrated as follows:

$$C_6H_5CF_3 + NaNO_3 + H_2SO_4 \rightarrow CF_3 \cdot C_6H_4 \cdot NO_2\ (1,3) + NaHSO_4 + H_2O$$

Finely ground sodium nitrate was added in small amounts from a porcelain spatula to the benzotrifluoride-sulfuric acid mixture. The reaction mixture was cooled by tap water and the sodium nitrate was added at such a rate that the temperature did not exceed 30°C. The reaction was finished off at 60°C. The experimental results are indicated in Table II.

TABLE II—YIELDS OF $CF_3.C_6H_4.NO_2$ 1,3

(Sodium Nitrate-Sulfuric Acid Method)

Per cent excess $NaNO_3$	Moles of H_2SO_4	Yield of $CF_3.C_6H_4.NO_2$ (1,3) in grams			
		Theor.	Crude	Pure	% (Pure)
0.0	2.74	95.5	88.1	78.0	81.6
10	2.5	95.5	91.8	82.4	86.2
10	2.74	95.5	89.5	83.7	87.6
10	3.0	95.5	98.2	82.9	86.8
10	4.0	95.5	87.5	81.4	85.2
10	5.0	95.5	89.7	79.9	83.6
10	5.0	95.5	88	81.9	85.8
20	2.92	95.5	89.8	85	89
20	2.92	95.5	88.9	85	89
20*	2.92	95.5	83.8	64.8	67.9
30	3.5	95.5	86.8	82	86
30	3.5	95.5	87.5	82.4	86.2

All nitrations were run at 25-30° and finished at 60° C.
* Not finished off at 60° C.

The yield of nitro compound is almost independent of the amount of sodium nitrate, 20 per cent excess being the optimum condition with only a slightly lower yield at 10 per cent. A H_2O to H_2SO_4 mol ratio is of no particular significance because of the large excess of acid needed to prevent the mixture from becoming too viscous as the sodium bisulfate progressively precipitates. Investigation of the mol ratio of H_2SO_4 to $C_6H_5CF_3$ with a 10 per cent excess of sodium nitrate showed an optimum yield of approximately 87.5 per cent at 5.5. The decrease in yield beyond this point is also probably due to sulfonation. A temperature of 25-30°C. was selected for convenience of control and it was necessary to finish the nitration at 60°, as indicated in Table II, in order to convert all of the sodium nitrate to nitric acid. The formation of the nitric acid at the end was indicated by the rapid rise in temperature.

In conclusion, the optimum conditions involve, (1) a 10-20 per cent excess of sodium nitrate, (2) a mol ratio of sulfuric acid to benzotrifluoride of 5.5, and (3) a temperature of 25-30°C. with a finishing off at 60°C. The maximum yield of pure product was 89 per cent.

Summary

It has been found possible to obtain meta nitrobenzotrifluoride in 90 and 89 per cent yields with concentrated nitric acid-sulfuric acid mixtures and sodium nitrate-sulfuric acid mixtures, respectively. A 10 per cent excess of nitric acid or sodium nitrate at room temperature was used.

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Progress in the Analysis of the Rare Earth Group

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For many years the analysis of the rare earth group for individual rare earth content proved to be one of the most difficult problems in rare earth chemistry. When we recall the great similarity in both the physical and chemical properties of their compounds we can readily understand why the analysis of this group has developed slowly.

The early analyst, restricted to methods of analysis which depended upon the chemical properties of the rare earths, reported only the total rare earth content of the ore or substance analyzed. Later when it was discovered that the rare earths could be separated into cerium and yttrium groups by means of the differences in the solubility of the double alkali sulfate, the percentages of these two groups were reported. In 1843 Mosander[1] found that cerium could be oxidized to a tetravalent state. This offers a means of estimating the amount of cerium present. Cerium in the tetravalent state is the least basic of the rare earths. Consequently if the cerium in a neutral rare earth solution is oxidized, hydrated cerio oxide precipitates upon boiling the solution. The cerium may then be determined gravimetrically. The advent of a number of suitable oxidation-reduction indicators had made it possible to determine the cerium volumetrically. Willard and Young[2] give a good review of the literature concerning the volumetric determination of cerium and have established the best conditions for the determination. With the exception then of a few isolated cases in which the lanthanum and didymium content, as determined by long-continued fractionation, was reported, the early analysis included only total rare earth, percentage of cerium earths and yttrium earths, and cerium content.

Within recent years the rare earth chemist has had at his disposal both physical and chemical means of analysis. Quantitative analysis based on physical measurements include the use of the x-ray and arc spectra, the magnetic susceptibility, atomic weight determinations, and solubility relationships. With the exception of the x-ray and arc spectra the physical methods are usually confined to binary or at the most tertiary mixtures. Our most important means for a complete analysis depend therefore upon the use of X-ray or arc spectra.

I. Noddack[3] has employed the x-ray spectra for the analysis of rare earth ores and artificial mixtures. The method consists essentially of measuring photometrically the intensity of certain line pairs of the spectra of rare earth and an internal standard. The intensity ratios between the selected line pairs are plotted against known concentrations of each rare earth. A spectogram is then taken of the sample and the intensity ratios determined. By referring to the graphs one may obtain the percentage of each earth present. The method is one of the most accurate of those we now possess.

B. S. Hopkins and co-workers[4] studied the use of the arc spectra as a means of analysis. The method is similar to that employed by Noddack. That is, the intensity ratios between the selected line pairs of rare earth and internal standard lines are determined by means of the microphotometer. These ratios are plotted logarithmically against concentration.

As previously mentioned, cerium has been determined for a long time by taking advantage of its anomalous valence. In 1930 Yntema[5] showed that europium and ytterbium could be reduced electrolytically in aqueous solution. This contribution to rare earth chemistry has prompted other chemists to investigate the chemistry of those rare earths which may be

reduced to the divalent state. McCoy[6] found that europium could be determined quantitatively by means of the Jones reductor. An acidified rare earth solution is reduced by zinc and passed into a standard iodine solution. The excess iodine is then determined by means of sodium thiosulfate. If the reduced europium is passed into a sulfate solution, insoluble europous sulfate precipitates. The precipitation however is not quantitative, consequently the volumetric method is preferred to the gravimetric. Brukl[7] by taking advantage of the anomalous valence of ytterbium has worked out a method for the determination of the ytterbium content of rare earth mixtures. The ytterbium is reduced electrolytically in an inert atmosphere. The reduced solution is then treated with an excess of ferric ammonium sulfate. The reduced iron is then determined by means of potassium permanganate.

Thus far chemical analysis has been confined to cerium, europium, and ytterbium. These methods depend upon the anomalous valences of the rare earths. Praseodymium for example may assume the quadrivalent state, samarium may be reduced to the divalent state. Valuable contributions to rare earth chemistry will be made when conditions are found in which these elements are stable in their anomalous valences. We will then have five members of the rare earths which may be determined chemically but what is more important we will have five members which may be separated from the complex of complexes—the rare earths.

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Research Environment

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AN ABSTRACT

Although it is commonly recognized that physical environment affects the productivity of ideas, it is very difficult to say just what specific physical conditions are most salutary to the generation of an idea involving industrial research. One thing, however, seems fairly certain: the research worker cannot "work unto himself alone." Exchange of ideas with others, through conservation or reading, is absolutely essential. To this end, a library well ventilated and lighted should always be close at hand and the worker given plenty of opportunity to make use of it. This method of gathering data should be augmented by conferences with other workers and authorities in related fields.

After the facts have been collected, the production of a new pattern from them cannot be hurried, nor the worker harried. An environment free of irritation is the prime requisite for an efficient solution of any research problem. Too often this environment is entirely lacking, and freedom from irritation is often sought through reading detective stories, or attending motion pictures. In an effort to take the edge off his worries (frequently economic and unsolvable until he makes more money) the worker finds that they still hang over his head like a Damocles' sword. Instead of feeling mentally refreshed, ready to tackle once more the research problem which is his job, he finds himself mentally exhausted. Concentration becomes laboured and forced, a thing of less and less moment. How can the tired mind function efficiently?

If only we could reproduce in a man's working hours the feeling of quiet and freedom from irritation that most people enjoy just before the day's grind—that clear early-morning feeling, relaxed and untrammeled with minutiae. An approximation of this state may be artificially but readily produced by providing the research worker with a comfortable room, air-conditioned, well lighted, free from a telephone, with sound-proofed walls and a lock on the door. Restful furnishings, and a pleasant view from the windows are helpful addenda. Few men are capable of continuous pattern-making for more than a few minutes at a time, and pleasant surroundings in contrast to drab ones interrupt the mind without irritating it. They allow the mind to return to the problem on hand refreshed rather than exhausted.

But the worker needs more than a pleasant place in which to think. He needs exercise. A convenient shower bath helps on sluggish days; vigorous physical labor in the plant does no harm and may be beneficial. Then, too, a change of scenery from time to time during the year (the traditional two-week period is viciously uneconomic) will keep him from growing stale and unprofitable.

Why not put our research worker on as efficient a working basis as we do the prize fighter. At present we expect him to do creative work on a nine-hour-daily production schedule: under such conditions he operates only fitfully after great mentally-destructive struggle against irritations. Apparently we can change this state of affairs, we can increase his momentary optimum of accomplishment if, instead of keeping him constantly straining against irritations, we provide him with a favorable environment. Mental relaxation, attained through lessened financial worry, restful surroundings, frequent conferences, frequent vacations, will clear the cluttered, harassed mind and leave it relaxed and ready to form spontaneous, new patterns of thought.

Modern Gasoline Refining

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The production of cracked gasoline now exceeds that of straight run and it has become the dominant motor fuel. This is in striking contrast to the conditions when cracking was first introduced. Cracked gasoline only with difficulty secured a place in the gasoline market. Its odor was not like that of straight run, it was yellow in color and it had a tendency to form gum.

Cracked gasoline could not be kept down, however, as it was soon found to be vastly superior to most straight run gasolines in antiknock value. The development of high compression motors of superior performance depended upon the availability of gasoline of high antiknock rating. In the great advances the automotive industry has made in recent years the provision of superior motor fuel by cracking has played a leading part.

At first cracked gasoline was heavily refined to make it look like the straight run product. Eventually, however, it was recognized that most of this refining simply wasted chemicals and caused loss of part of the gasoline. Insistence on water white color was found to be a useless fetish, as it makes no difference to a motor whether gasoline is white or yellow, and dyed gasoline suits fully as well as a highly refined product. Low sulfur was found to be an unnecessary requirement, particularly in warm climates. In many parts of the country the specification of one-tenth percent is entirely obsolete and it is only adhered to in some places because of the rigidity of state regulations. The only two useful ends which refining cracked gasoline serves are the production of motor fuel of good odor which will not form gum.

The unpleasant odor of some cracked gasolines is due to the presence of mercaptans. These may sometimes be largely removed by repeated washing with caustic soda, which forms mercaptides according to the equation

$$RSH + NaOH \rightarrow RSNa + H_2O \qquad (1)$$

Caustic soda will only remove the lower mercaptans and these only until it is partially saturated. For economy therefore, the caustic is regenerated, i.e., boiled to cause reversal of the reaction and liberation of the mercaptans in gaseous form. The caustic may then be reused for a number of cycles. After this treatment some gasolines are marketed, but usually further removal of mercaptans is brought about by what is known as sweetening. This is usually treatment with doctor solution (sodium plumbite) and sulfur. The reactions occurring are:

$$RSH + Na_2PbO_2 \rightarrow RS\ PbO\ Na + NaOH \qquad (2)$$
$$2RSH + Na_2PbO_2 \rightarrow (RS)_2Pb + 2NaOH \qquad (3).$$

On addition of sulfur polysulfide-lead compounds are first formed, following reactions (4) and (5):[1]

$$(RS)_2Pb + S \rightarrow RSS\text{-}Pb\text{-}SR \qquad (4)$$
$$(RS)_2Pb + 2S \rightarrow RSS\text{-}Pb\text{-}SSR \qquad (5)$$

These complexes break down according to reaction (6):

$$RSS\text{-}Pb\text{-}SR \rightarrow RSSR + PbS \qquad (6)$$

or if excess sulfur is used, probably according to reactions (7) and (8):

$$RSS\text{-}Pb\text{-}SR + S \rightarrow RSSSR + PbS \qquad (7)$$

$$RSS\text{-}Ph\text{-}SSR + S \rightarrow RSSSR + PbS \qquad (8)$$

When the doctor reaction goes as desired only reaction (6) occurs and the mercaptans are converted into disulfides. However, if an excess of sulfur is used, reactions (7) and (8) take place, and probably in any case, some trisulfides remain in the gasoline. The presence of polysulfides reduces the antiknock value of the gasoline and at least the higher polysulfides lessens the response of the gasoline to inhibitors. For this reason sweetening should be carried out with the least possible amount of sulfur and this is aided by efficient mixing of the reagents with the gasoline.

While the larger part of the gasoline of the country is sweetened with doctor solution a newer process employing copper salts is rapidly coming into wide spread use. In this process, the essential reactions are (8) and (9):

$$Cu^{++} + RSH \rightarrow RSSR + H^{+} + Cu^{+}$$

$$2Cu^{+} + 2H^{+} + O_2 \rightarrow H_2O + 2Cu^{++} \qquad (9)$$

The gasoline is first brought in contact with the copper salts, which oxidize the mercaptans to disulfides. Either at the same time or in a separate step the reagent is blown with air to reconvert the cuprous copper to the cupric form.

Prevention of gum formation in cracked gasoline has long been brought about by treatment with sulfuric acid or fullers earth. A more economical method of securing gum stability is the addition of an oxidation inhibitor, which prevents loss of hydrocarbons, saves the loss in antiknock value usually caused by chemical refining, the cost of reagents and of operating treating process. Much of the gasoline now sold is given no treatment beyond sweetening and adding inhibitor. Such gasoline often changes less in storage than motor fuel refined by other methods. Aminophenols, naphthols, and wood tar fractions are the most widely used commercial antioxidants. Their use is steadily increasing and probably will eventually largely replace other treating methods.

[1] Ott and Reid, Ind. Eng. Chem. 22, 884 (1930).

Ammonolyzed Epinephrine Conjugates and Their Pressor Action in Dogs

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When epinephrine is treated with anhydrous liquid ammonia an ammonolyzed derivative is formed (1). This new product on intravenous injection causes a more prolonged (50% longer) elevation of blood pressure in dogs than epinephrine, although the extent to which the pressure is elevated is approximately the same. Because this is obviously a desirable pharmacological feature of the new product, an attempt has been made to augment this feature by conjugating one of the normal constituents of blood plasma with epinephrine.

The substances chosen to be conjugated with epinephrine were glycine, tyrosine, glutamic acid, urea, lactic acid, dextrose, cebione and cholesterol. Liquid ammonia was used as a solvent and dispersing medium because the changes wrought by conjugation in liquid ammonia are generally more marked than those obtained by ammonolysis alone. For example, by conjugating glycine with hematin in liquid ammonia a compound is formed which retains the properties of the original pigment and yet is soluble in water at pH 7.0 to 7.4.

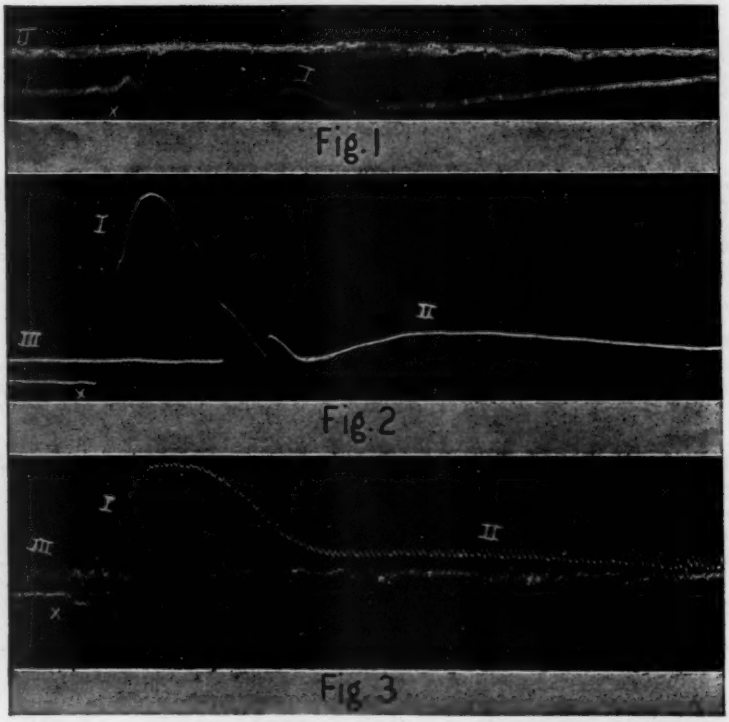
Methods: The method used was essentially the same as that described in the first paper (1). The liquid ammonia was dried over sodium by the method of Fernelius and Johnson (2). The combined sample (epinephrine plus the substance to be added to it) used for a single reaction was usually less than 0.5 gm. The reaction was carried out in a heavy walled, transparent Dewar flask which was attached to a mercury seal so that the excess liquid ammonia could boil off without moisture being admitted to the epinephrine. This required about 24 hours. 200 cc. of liquid ammonia were used. The Dewar flask was then attached to a vacuum pump until the odor of ammonia was removed. The flask was not heated. The dry powder was then ready for use, and was made up to a concentration of one mgm. per cc. in terms of its epinephrine content. Distilled water and ethylene glycol were the only vehicles used. Glycerol was abandoned as a vehicle in favor of ethylene glycol due to the lower viscosity of the latter.

Dogs weighing about 12 kgm. were used to assay the new compounds. The injections were made into the femoral vein, and the carotid blood pressure was measured by the customary method. Ether and sodium phenobarbital were the anaesthetics used. At least twenty minutes were allowed to elapse between injections.

Results: It was found that epinephrine dried to constant weight in a vacuum desiccator over sulfuric acid is essentially insoluble in liquid ammonia in a concentration of 25 mgm. of epinephrine to 200 cc. of liquid ammonia. The powder swells slightly and becomes darker, and the liquid ammonia continues to boil faster for thirty minutes or more indicating some kind of an exothermic reaction between the epinephrine and the liquid ammonia.

Glycine is exceedingly soluble in liquid ammonia and when epinephrine is added to such a solution of glycine in ratios of 0.5 to 10 moles of glycine to one of epinephrine, the epinephrine is brought into solution or is very finely dispersed, and the clear solution becomes yellowish. A light flocculent precipitate then forms quickly, but does not begin to settle for an hour or more, although epinephrine itself settles immediately. The new product in concentrations of 1:1000 is not entirely soluble in either water or ethylene glycol, but it can be injected in the form of a finely dispersed sol. Water

can be used as a vehicle, but the injection must be made at once as the desiccator. Observing the above precautions, the glycine and epinephrine of obtained. In ethylene glycol, however, the derivative remains active for weeks, even in an open beaker. The activity is retained in glycerol also. The dry powdered derivative retains its activity in well stoppered bottles or sealed ampoules, but loses it when kept over sulfuric acid in a vacuum desiccator. Observing the above precautions, the glycine and epinephrine of equal molar proportions gives when injected intravenously a blood pressure



EXPLANATION

Fig. 1. X = Base line and site of injection. I = Rise from below base line following primary excursion and continuation upward. II = Elevation reached by rise I, and maintained for one hour when drum was stopped. Time of drum for one rotation was twenty-five minutes. Ether anaesthesia was used. Dose used was 0.25 ccc. of 1:1000 epinephrine equivalent for a 1:1 molar conjugate of epinephrine and glycine. The vehicle was glycerol.

Fig. 2. X = Base line and site of injection. I is the primary excursion. II marks the prolongation of the secondary which did not fall below the base line. III is a continuation of rise II after twenty-five minutes. Ether anaesthesia was used. Dose used was 0.25 cc. of 1:1000 epinephrine equivalent for a 1:1 molar conjugate of epinephrine and dextrose. The vehicle was ethylene glycol.

Fig. 3. X = Base line and site of injection. I is the primary excursion. II marks the prolongation of the secondary which did not fall below the base line. III is a continuation of rise II after twenty-five minutes. Sodium phenobarbitol anaesthesia was used. Dose used was 0.25 cc. of 1:1000 epinephrine equivalent for a 1:1 molar conjugate of epinephrine and cholesterol. The vehicle was ethylene glycol.

curve that in a general way resembles the curve of the epinephrine control, but the peak of the primary curve is less sharp and the secondary portion of the curve is much prolonged. The secondary portion of the curve may return to the control blood pressure level or even pass below it within five to ten minutes as with epinephrine, but on rising again it does not remain on the base line, but continues to rise above it reaching an elevation of ten to fifty per cent of that of the initial rise, and maintaining such an elevation from one to three hours. The product resulting from the mole for mole proportion of epinephrine and glycine produced a more prolonged rise in pressure than the others; the other glycine derivatives produced a more prolonged blood pressure rise than epinephrine. (See Fig. I).

Other amino acids, such as tyrosine and glutamic acid, react with epinephrine in liquid ammonia to form derivatives that give a sustained rise in blood pressure. However, the secondary sustained rise in pressure is in general not as great as with the one to one epinephrine and glycine. Aihara and Ito claim potentiated adrenaline constriction of the perfused rabbit ear by the addition of aspartic acid or asparagine to the adrenaline perfusate. (4) We have used such mixtures for our control injections, and we have found the prolongation to be very slight or negligible.

Dextrose and cholesterol both form derivatives with epinephrine and these give a prolonged pressor action, although their mode of formation is somewhat different. Cholesterol and epinephrine are slightly soluble and form a derivative that is slightly soluble in liquid ammonia. Dextrose is exothermically very soluble, and forms a soluble derivative with epinephrine. Both of these derivatives produce a prolonged rise in blood pressure, and the secondary portion of the curve does not fall below the control blood pressure. (See Figs. 2 and 3).

Cebione or vitamin C is exothermically soluble in liquid ammonia, and forms a derivative with epinephrine that is soluble. This derivative does not have a prolonged pressor action, but it possesses a property that seems to be unique among the compounds examined. When left in an open beaker dispersed in ethylene glycol, it does not turn pink or red as do all of the other derivatives mentioned, but retains its original faint lemon yellow color for weeks; its pressor activity remains undiminished after a month. When left in water it turned red as did the other compounds, which is probably due to the liberation of epinephrine by hydrolysis.

The ease with which our ammonolyzed epinephrine conjugates hydrolyze might indicate that they are coordination products formed through the latent valences or hydrogen bridges (3) of the nitrogen in the liquid ammonia. They are quite stable when sealed or dispersed in ethylene glycol, however, and their long sustained pressor action indicates that they are not easily broken down in the blood. Our products have shown no evidence of being toxic, and due to their prolonged action over that of epinephrine they should prove to have a therapeutic value as hemostatics and as drugs for the treatment of hay fever and asthma.

SUMMARY

Conjugation products of epinephrine with glycine, tyrosine, glutamic acid, urea, lactic acid, dextrose, cholesterol and cebione have been made by using liquid ammonia as a solvent and dispersing agent. All the products, except that with cebione, produce a more sustained rise in blood pressure than epinephrine; in this regard the products made with glycine, dextrose and cholesterol are most potent.

The authors wish to thank the following companies for their generosity in furnishing materials: Parke Davis and Company for the adrenaline, Hoffman-LaRoche for the vitamin C and Merck and Company for the cebione.

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Structural and Chemical Similarities of Hydrogen Peroxide, Hydroxylamine and Hydrazine

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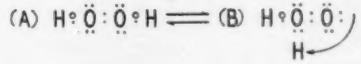
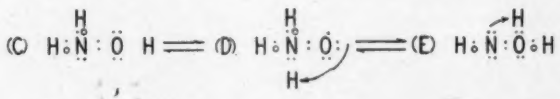
A comparison of the nitrogen and the oxygen systems of compounds leads to the conclusion that hydrogen peroxide, hydroxylamine, and hydrazine are related structurally, since the –OH and $-NH_2$ radicals are isosteric. Chemically, each of these compounds behaves both as an oxidizing and a reducing agent; hydrogen peroxide, primarily as an oxidizing agent, while hydroxylamine and hydrazine find application chiefly as reducing agents.

Hydrogen peroxide tends to behave as a strong oxidizing agent in neutral and alkaline solution, but in acid solution does exhibit the properties of a reducing agent. This observation is explained readily by application of the Bronsted concept, since it may be assumed that removal or wandering of a proton must take place before the hydrogen peroxide molecule can release oxygen readily. Two tautomeric structural formulas have been proposed.



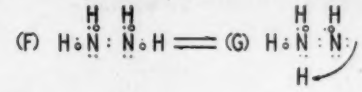
The compound with structure (B) should act more readily as an oxidizing agent since the second oxygen atom is held by a coordinate link. In this state it may be represented by the formula: $H_2O \rightarrow O$. The molecule (B) would form only if the proton were permitted to wander, a tendency which would be suppressed in a solution containing acid. In aqueous solution hydrogen peroxide is a very weak acid and practically any base will remove the proton with formation of the OOH^- ion, which is evidently a strong oxidizing agent.

In the case of hydroxylamine several structures are possible:



Of these (D) is more probable than (E) as nitrogen has a higher proton affinity than oxygen. However, (E) is not necessarily ruled out. Structure (D) is known in the amine oxides, where the oxygen is held by a coordinate covalency: $R_3N \rightarrow O$. The ability of hydroxylamine to act as an oxidizing agent in water solution is not great, due to the fact that it is more basic than water. There is little or no tendency on the part of water to remove a proton from the hydroxylamine molecule to give an ONH_2^- ion. The reverse tendency is so great that solutions of NH_2OH in water contain an appreciable concentration of $NH_2OH \cdot H^+$ ions. A much stronger base than water would be required to remove the proton, or even to permit proton migration in the molecule to give the tautomeric amine-oxide structure. Hence, hydroxylamine acts primarily as a reducing agent in aqueous solution, since it exists overwhelmingly in the molecular form depicted by structure (C).

In the case of hydrazine, two forms are possible:



Theoretical considerations indicate that N_2H_4 may exist in the ammonium imide ($NH_3 \rightarrow NH$) (G) form in the vapor state. That this tautomer (G) is capable of existing in any quantity in aqueous solution is highly improbable, since the hydrazine molecule is a strong base and may even add two protons, as in the formation of the dihydrochloride. Hence, in aqueous solution an exceptionally strong base would be required to effect the proton removal or migration necessary to allow hydrazine to act as an oxidizing agent.

There thus appears to be a qualitative relationship between the pH of the solution and the ability of these compounds to act as oxidizing or reducing agents. To act as oxidizing agents proton migration, or proton removal is necessary. As the basicity of the molecules increases in the order $H_2O_2 < NH_2OH < N_2H_4$ the east with which proton removal or migration is effected decreases correspondingly. While these considerations define the general behavior of these three related compounds, it should be pointed out that the redox equilibrium is a relative one and exceptions may occur depending upon the oxidizing or reducing strength of the other reactant.

Application of the Bronsted concept suggests that both hydroxylamine and hydrazine may act more effectively as delectronators (augmenting or oxidizing agents) in more basic solvents such as ammonia and the amines; whereas all three compounds will presumably act only as reducing agents in acid solvents such as glacial acetic acid. Coexistence of both tautomers may in turn be expected in amphiprotic or aprotic non-aqueous solvents.

Sulfamic Acid and Its Derivatives

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Sulfamic acid, H_2NSO_3H, is related structurally to sulfuric acid and may be looked upon as a mixed ammono aquo sulfuric acid. It is a white, crystalline, non-hygroscopic solid, melting with decomposition at 205°. It is only moderately soluble in water and may be purified by recrystallization from cold water. In aqueous solution the acid is highly ionized.

Sulfamic acid has been investigated for use as a primary standard of reference. It is superior in this respect to such acid standards as constant boiling hydrochloric acid, potassium acid iodate, potassium acid phthallate and benzoic acid. A wide variety of indicators over a pH range of 5 to 9 may be used in standardizing bases with sulfamic acid.

Sulfamic acid is very soluble in liquid ammonia, being converted into the ammonium salt. Sulfamic acid acts as a dibasic acid in liquid ammonia.

Amine salts of sulfamic acid may be prepared by interaction of the amines in aqueous or alcoholic solution with sulfamic acid. These are stable crystalline solids, differing in some instances from the inorganic salts by the fact that they are somewhat hygroscopic.

Alkyl and aryl sulfamic acids are most conveniently obtainable by interaction of the amines with chlorosulfonic acid. Preparations of this type must be carried out in non-aqueous solvents such as dioxane, chloroform, and carbon tetrachloride. Derivatives of N-disubstituted and N-monosubstituted acids, R_2NSO_3H and $RNH \cdot SO_3H$, have been prepared and their properties investigated.

Convenient laboratory methods for the preparation of free sulfamic acid include (1) the hydrolysis of nitrilosulfonates, and (2) action of sulfur dioxide on hydroxylamine salts or acetoxime. Commercially, sulfamic acid is prepared by the action of fuming sulfuric acid upon urea. The introduction of this method has made sulfamic acid really available on the market, at a price where it should find wide use and application in synthetic and analytical chemistry.

Inorganic Salts in Biochemistry

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Almost eighty years ago, Lord Lister wrote in his studies on "Early Stages of Inflammation," "It appears to me, we have a sure though imperfect glimpse of the operation of mysterious but potent forces, peculiar to the tissue of living beings and capable of reversing the natural order of chemical affinities, forces which I suspect will never be fully comprehended and the study of which should always be approached with humility and reverence." We talk today of catalysis, hormones, and vitamines. Their nature and origin (1), still not entirely known, is based on the physico-chemical structure of the human body: i.e. (a) the colloid character of the medium (hydrophilic and hydrophobic colloids), (b) the solubility and distribution of the crystalloids in the colloids; their mutual influence and their influence on the dispersion, lysis, condensation, and hydration of the colloids, (c) the conduction of chemical and physico-chemical potential differences through the nervous system; the central nervous system and the autonomic nervous system (sympathetic and parasympathetic).

This paper deals only with one small section of the entire problem: the inorganic salts (ionized elements). The accumulation of certain physiological ions in different organs, even in different structures of the same organ, produces a chemical and physico-chemical tension which is fundamental for the function of the organ. The subject will be treated as follows:

I. Distribution of inorganic salts (ionized elements) in different organs
II. Functional value of cations and anions
III. Regulation and distribution of ions by hormones, and influence of ions on hormones
IV. Vitamines and ions.

I. Distribution

The distribution may be seen from Table I, which shows the ratio of cations and of anions computed from different sources (2). Whether their compounds are organic or inorganic is not of great importance as long as they act as ions. Even their insoluble stable compounds, such as calcium phosphate and calcium carbonate dissociate constantly, exchanging their ions with the blood and lymph streams which carry the acid phosphates and carbonates of sodium and potassium. There is a biological association of certain ions, which as a rule, prevails in the same tissues; e.g. Na^+ and Cl^-, K^+ and PO_4^{---}. The same is true between ions and colloids; e. g. K^+ and lecithin which coexist throughout the entire plant and animal structures, Na^+ and cholesterol which are frequently found together in one and the same organ or in body fluids, and Cu^{++} and vitamine B which are always associated (3).

II. Function

Extremely small quantities are often of high functional value; Cu^{++}, Mn^{++}, and I^-. Chemically related ions (K^+, Na^+, Ca^{++} and Mg^{++}) frequently function as antagonists, although they may replace each other or may have

TABLE I—RATIO OF CATIONS AND OF ANIONS FROM VARIOUS SOURCES

	Na^+:K^+	Ca^{++}:Mg^{++}	Other Cations	Cl^-:P_2O_5	Other Anions	Cholesterol :Lecithin
Human body	1:2	30:1	Fe^{++}, Mn^{++}, Cu^{++}, NH_4^+	1:7	CO_3^-, S_2O_3, NO_3 I^-, Br^-, Fl^-	
Milk	1:4	5:1		1:1½	I^-	Fat
Blood						
Plasma	10:1	3:2		60:1	CO_3^-	>
Erythrocytes	1:4	/ /	Fe^{++}>Cu^+	0:+		<
Leucocytes (pus)	1:2	2:1	Fe^{++}<Cu^+	1:20	$S_2O_3^-$, NO_3	<
Brain						
White substance	+:0	1:3	Fe^{++}	>	Br aggregated in pituitary	> Cerebrin
Gray substance	0:+ 1:2½			< 1:2		<
Nerve cells	+:0					
Axis cylinder	0:+		NH_4^+			
Sciatic nerve	1:2½					
Retina	+:0		Fe^{++}	<		
Cerebrospinal fluid	30:1			+:0		
Skeleton		80:1		1:400	CO_3^-	< Fat
Bone marrow	<		Fe^{++}, Cu^+	<		
Teeth						
Dentine		<		1:30	CO_3^-	
Enamel		>				
Skin	>			>		
Nails, hair		Ca^{++}	Fe^{++}		$S_2O_3^-$	
Sweat	>			700:1	$S_2O_3^-$	
Lacrymal secr.	+:0			+:0		
Sebaceous secr.		Ca^{++}		P_2O_5		
Muscle (Striated, heart and smooth)	1:24	1:4	Fe^{++}, NH_4^+	1:3	$S_2O_3^-$	
Lung	20:1	1:1	Fe^{++}	1:6	>	
Digestive tract						
Saliva	1:5(1:1½)	33:1(6:1)		1:1	$S_2O_3^-$, Fl^-	
Gastric juice	1:1	+:trace	Fe^{++}, NH_4^+	2½:1		
Pancreatic juice	300:1	1:1		22:1		
Pancreas	1½:1	10:1	Mn^{++}	18:1		
Bile	10:1	3:1	Fe^{++}, Cu^+	8:1		1:1(1:3)
Liver (child)	1:3	5:1		1:10		
Liver (adult)	1:1½	15:1	Fe^{++}, Mn^{++}	1:20	$S_2O_3^-$	
Spleen						
Male	4½:1	14:1	Fe^{++}, Cu^+	1:50		
Female	2:1	14:1	Fe^{++}, Cu^+	1:20		
Kidney		4:1	Fe^{++}, Mn^{++}	1:2½		
Urine	2½:1	1½:1		3½:1	$S_2O_3^-$, etc.	

a synergistic function in other respects. Certain units (Na^+, Cl^-; Na^+, cholesterol) are often aggregated in organs side by side, but separated from their antagonists (K^+, lecithin; K^+, phosphate), which results in a high potential difference (white and grey substance of brain; organ cells and body fluids; brain and spinal fluid). The importance of the equilibrium between ions can easily be demonstrated.

a. the respiration quotient, $\frac{CO_2}{O} = 1$, is increased by feeding dextrose, but much less by feeding dextrose with mono- or disodium phosphate (Fig. 1). This is explained (Fig. 2) by a deficiency of glycogen formation (4).

b. the proportions, $(Na^+ + K^+) : (Ca^{++}, Mg^{++} :: 50:1$, and $K^+ : Ca^{++} :: 1:2$ are essential in the maintenance of the heart beat and the irritability of cellular elements in general (5).

c. the ratio, $(K_2HPO + KH_2PO_4) : (Ca^{++} + Mg^{++})$, is a stimulus for the respiratory center, the irritability of which is increased by an increase in the quotient and is decreased by a decrease in the quotient. This ratio can be influenced either by X-ray treatment (6), by adrenalin injection (7), by splenectomy or sympathectomy, or by resection of the pancreatic duct (8).

The functional significance of the presence and of the prevalence of certain ions in the different structures will be shown in a few examples. A study of Table I and more detailed analyses would furnish much more material. The purpose of this paper is to initiate these studies. A brief survey of the tabulation will, however, aid in making the study a little easier.

Milk, the simplest food, may be compared with the needs of the human body (Table I), and we see a parallel occurrence and prevalence of ions. More detailed studies reveal that human milk contains iodine during the first five days of lactation (9). This fact, as a rule, is entirely overlooked when cow's milk is given (Fig. 3) during the first days of lactation. This may account, in part, for the high mortality of children not fed with mother's milk during the first week.

The erythrocyte contains, closely aggregated into a cell nine micra in diameter, all the ions necessary for, and favorable to oxidation-reduction; Fe^{+++}, K^+, PO_4^{---}, with oxygen attached to the hemoglobin, and with lecithin as the vehicle. The nuclei of the leucocytes are relatively rich in copper; the plasma is rich in NaCl, Ca^{++} (blood coagulation), cholesterol, with phosphates and carbonates as buffers. For further details, see Pribram (10).

The high functional differentiation between brain and nervous substance is characterized by the absence of Na^+ in the grey substance and in the axis cylinder, and the absence of K^+ in the nerve cell and in the white substance of the brain. The prevalence of Cl^- and PO_4^{---} corresponds, as a rule, to that of Na^+ and K^+ respectively. There is, however, an exception. The retina contains Na^+ and Fe^{++} instead of K^+, and is rich in PO_4^{---} which plays a role in the activation of retinoflavin.

The stable chemical structure of the bone and the unstable structure of the bone marrow with its high functional (reproductive) activity, are striking examples of the significance of the distribution of ions in the body. The teeth show a prevalence of calcium in the enamel and of magnesium in the dentine. Further work is needed to find the functional significance of this fact.

The skin has the most complicated structure of all organs; each layer responds differently to ions, and each layer aggregates different ions. Even different concentrations influence the closely related fibres of the skin differently. Connective tissue responds to diluted NaCl with hydration; collagene fibres to concentrated NaCl. The most potent hydrator of the skin is iodine; the most potent dehydrators are SO_4^{--} and CO_3^{--}. The anions, therefore, regulate the water content of the skin. Sweat glands and lachrymal glands aggregate NaCl while hair and sebaceous glands aggregate calcium.

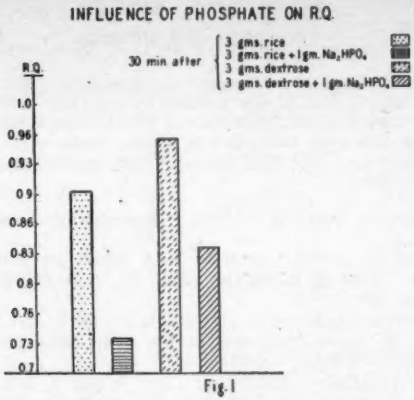

Fig. 1

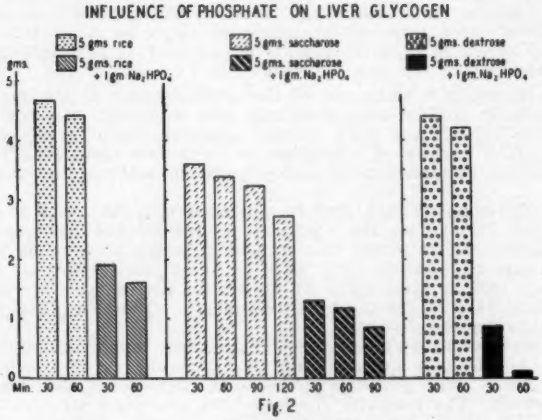
INFLUENCE OF PHOSPHATE ON LIVER GLYCOGEN
5 gms. rice
5 gms. rice + 1gm Na2HPO4
5 gms. saccharose
5 gms. saccharose + 1gm. Na2HPO4
5 gms. dextrose
5 gms. dextrose + 1gm. Na2HPO4
gms.
Min. 30 60 30 60 30 60 90 120 30 60 90 30 60 30 60

Fig. 2

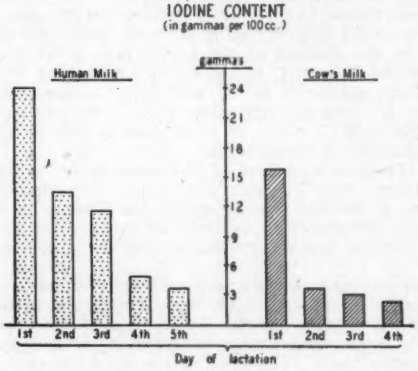

Fig. 3

The influence exercised by each of the constituents of the blood on the function of the heart muscle has been thoroughly studied by Ringer (11). See also Langendorff (12). Inorganic salts play the main role here. The antagonisms of K^+ and Ca^{++}, K^+ and Na^+, Ca^{++} and NH_4^+ are striking. The importance of the K^+ for diastole and of the Ca^{++} for systolic contraction are well established. K^+ acts as a radioactive substance and can only be replaced by radioactive substances or by beta-rays. The primary stimulus for the contraction of muscles is NH_4^+ (13). Charles Darwin (14) observed that 1/20,000 of a grain (= 3.3 grammas) of $(NH_4)_3\,PO_4$ causes flection of almost all the tentacles of drosera. Prawdicz-Neminski showed that relaxation of the muscle, after contraction by the ammonium salt, is caused by the formation of the double salt with Mg^{++}. Twenty mg of $MgCl_2$ (6 H_2O) and 0.25 mg of NH_4OH to 100 cc. of Ringer's solution are sufficient to counteract exhaustion of the heart muscle. The salt is soluble in lactic acid, and is removed from the muscle after contraction. The periodic contractions of striated muscle find here their explanation. All the ions are present in the muscle fibre; phospho-creatine being the source of NH_4^+ and PO_4^{---}, Mg^{++} also being present in relatively large quantities (Ca^{++}:Mg^{++}::1:4). NH_4^+ is present in the intestinal tract, and preponderant in the vena cava superior since its blood does not pass the liver. The blood of the vena cava inferior, after having passed the liver, contains less NH_4^+. A high potential difference between the two venae cavae arises from this fact. In addition, the blood of the vena cava superior is emptied at the most sensitive spot of the heart, the Keith-Flack node (15). The vagus nerve likewise enters the heart at this area. Ammonium salts are accumulated by nerve tissue, which is thirteen times richer in NH_4^+ than muscle tissue, and, in the active state, even fourteen times (16).

The importance of the exchange of K^+ against Na^+ for the distribution of water (shifting to the inner organs) during fever has been emphasized by the author (17).

The lung tissue, different from all the other organs, is very rich in Na^+. The prevalence of phosphates over chlorides is remarkable in this connection. It may be due to the Ca^{++} and Mg^{++} content. The ventilation of the blood by the lung governs the CO_2 balance and, indirectly, the acid-base balance of the blood.

In the digestive tract we have the saliva, very rich in K^+, especially if undiluted and the urea, containing the balanced CO_2-NH_3 compound, a potent solvent. In the gastric juice we find HCl, unique in living tissue. It is formed by a relatively simple chemical process: $H_2CO_3 + NaCl = HCl + NaHCO_3$ (18). This reaction involves an automatic regulation of the CO_2 tension in the blood, which tension is the stimulus for the respiratory center.

The liver, extremely rich in K^+, harbors the bile which is rich in Na^+ and cholesterol. The importance of the ratio $(K^+ + Mg^{++}):Na^+$ in the liver may be learned from Fig. 4 in which the Na^+, K^+ and Mg^{++} contents of the normal liver, of the liver in pregnancy, and in eclampsia are compared (19).

The spleen is rich in Na^+ and in phosphates, especially in the male, less in the female. The kidney takes care of the removal of all ions from the body.

III. Regulation and Distribution of Ions by Hormones, and Influence of Ions on Hormones

Fig. 5, in which the cations and the anions are combined with those organs in which they prevail and in the function of which they play an important role, shows the coordination of certain groups of organs and the interrelation of their ionic function. Fig. 6, in which the physiological cations and anions are connected with the endocrine glands (hormones) and with the vitamines (A, B, C, and D) to which they have relation, shows the coordination of hormones, vitamines and ions. It is evident from these diagrams that each ion has a specific projection in certain organs and endocrines, such as the I^- in the thyroid, the NH_4^+, Ca^{++}, Mg^{++}, CO_3^{--}, and PO_4^{---}

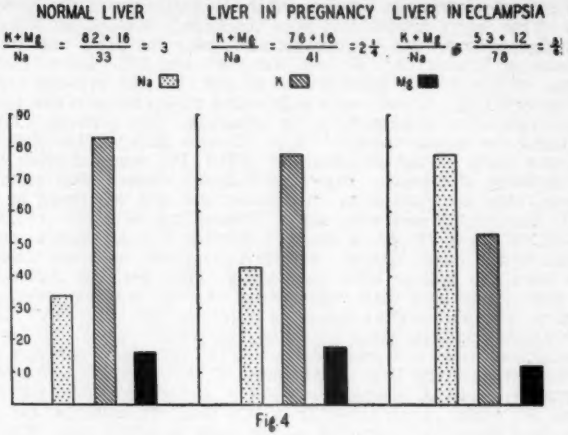

Fig. 4

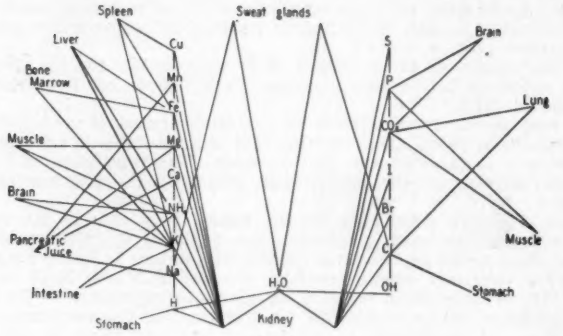

Fig. 5

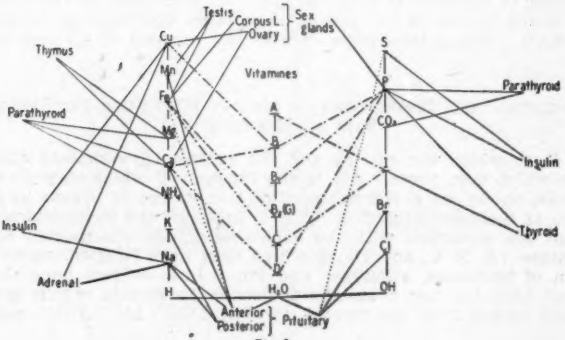

Fig. 6

in the parathyroid. Synergistic hormones and ions are to be found. Examples are: Na^+ and insulin (20), Na^+ and adrenalin (21). This means that the simultaneous administration of Na^+ and the hormone is equivalent to a larger quantity of the hormone.

The distribution of certain ions is controlled by hormones, such as that of Na^+ and of Ca^{++} by the anterior pituitary gland; that of K^+ and of Na^+ by the posterior pituitary gland, which shifts the ions to skin, liver, and circulation. The Mn^{++}, likewise controlled by the pituitary gland, has a fundamental importance in the development of the testis (22). Complete lack of Mn^{++} in the food causes degeneration of the testes in male rats. After 100 days the rapidly progressive degeneration leads to a complete atrophy of testes. Five mg. of Mn^{++}, added to the same diet, are sufficient to prevent the testicular atrophy (23). In the female, Mn^{++} and dextrose are necessary to maintain the normal oestrus cycle. The anterior lobe of the pituitary gland evidently needs Mn^{++} as a stimulus for the production of its hormone.

IV. Vitamines and Ions

Vitamines (dotted lines) have definite affinities to certain ions, such as vitamine D to Ca^{++} and PO_4^{+++}, vitamines C and B_2 to Fe^{++}, and vitamine A to I. The two diagrams, Figs. 5 and 6, combined, in three dimensions would give a model of the simultaneous cooperation and interrelation between organs, including the ductless glands (hormones), vitamines, and ions. This would offer "an imperfect glimpse of the operation of some of the potent forces peculiar to the tissue of living beings."

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PAPERS IN GEOGRAPHY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The Geography Section carried nine papers, five of which are herewith presented. The other three were:

Some Natural Bridges of Southern Illinois, by Flemin Cox, Southern Illinois State Normal University, Carbondale.

Mineral Relationships in the Mediterranean, by Walter H. Voskuil, State Geological Survey, Urbana.

Mathematics in Geography, by Raymond Huck, Township High School, Centralia.

Great landed estates in the Mediterranean area, by Raymond E. Crist, University of Illinois, Urbana.

About 35 attended the meeting.

Thomas F. Barton, Southern Illinois State Normal University, Carbondale, Illinois, was elected Chairman of the Section for the 1939 meeting.

(Signed) R. E. CRIST, *Chairman.*

Some Geographic Aspects of Soil Erosion in Illinois

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Southern Illinois State Normal University, Carbondale, Illinois

To most laymen a map of Illinois (Fig. 1[1]) showing the areas that are subject to erosion may be a dull and meaningless pattern, but to some geographers such a map would stimulate them into attempting to interpret the distribution and seriousness of the eroded areas in terms of physical environmental factors.

State Distribution of Soil Erosion

Most of the soil erosion in Illinois is found in the west-central and southern part of the State. Looking on a map at the location of the 16 counties having over 75 per cent of the areal surface affected by erosion of a "serious" and "destructive"[2] nature, we find that the Ozark Ridge runs through 6 of them, and that 2 are influenced by the rough terrain in the northwestern part of the State. Of the remaining 8 counties, 6 are found by the Illinois River, one is badly eroded by three forks of the Big Muddy River, and the last is sandwiched between the Little Wabash and Saline rivers.

In contrast with the 16 badly eroded counties in the south and west-central part of the State are the 21 counties in the northeastern part having less than 11 per cent of their area affected by erosion of a "serious" and "destructive" nature. Not one of these 21 counties lies south of where the Wabash River becomes the eastern boundary of Illinois. It is interesting to recall that at one time most of these counties were covered with a prairie vegetation. It is also interesting to note that these 21 negligibly eroded counties generally occupy the more level terrain. Many of them, in fact, are so level that at one time they contained large swampy areas presenting drainage problems to the pioneers.

Besides comparing the badly eroded counties with the slightly eroded ones, a contrast of soil erosion made in the 24 northernmost counties with the 24 southernmost ones proves that erosion is more serious in southern Illinois. The following table gives the extent and seriousness of soil erosion in the two extremes of the State.[4]

Area Affected by Serious and Destructive Erosion

	Northern 24 counties	Southern 24 counties
More than 75 per cent	2	8
51 to 75 per cent	1	9
26 to 50 per cent	4	4
11 to 25 per cent	4	3
Less than 11 per cent	13	0
	24	24

Perhaps the most significant fact to be gained from this table is that over half of the 24 counties to the north have less than 11 per cent of their land affected by erosion of a "serious" and "destructive" nature while over two-

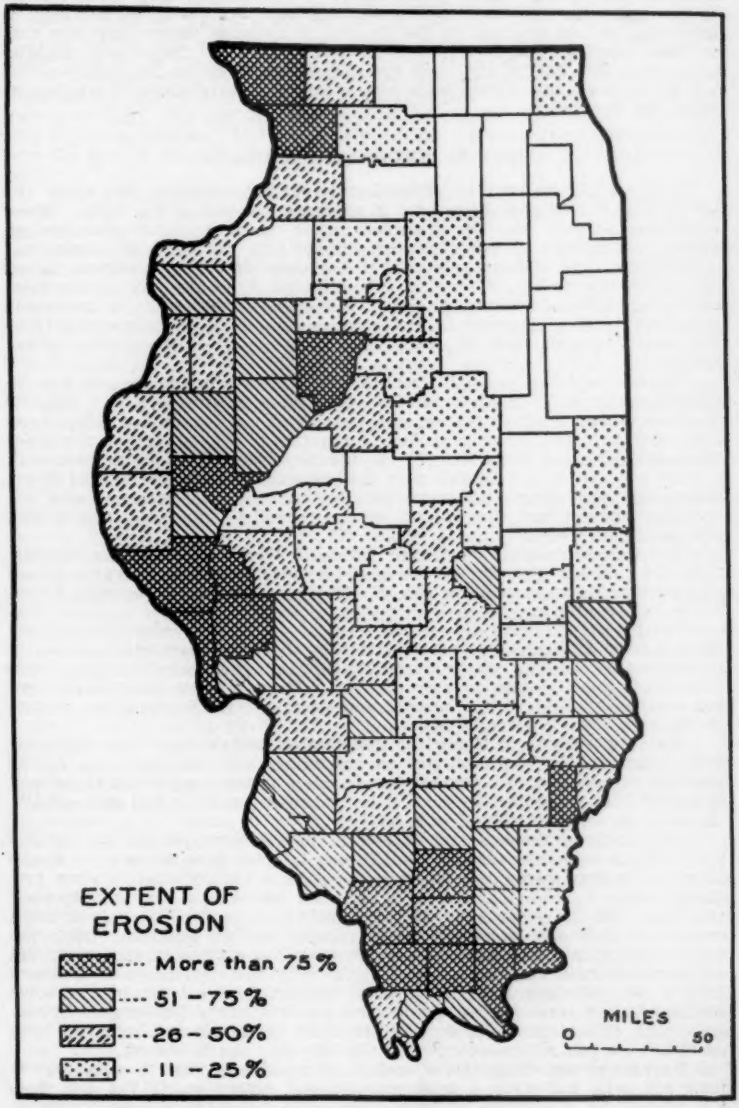

Fig. 1—Extent of Erosion in Illinois.

thirds of the 24 counties to the south have over half of their land affected by the same type of erosion. Looking at these figures we should bear in mind that we are contrasting the number of counties rather than the area in these counties. However, we should also remember that the 24 counties in the northern part of the State are larger than those to the south—a fact which increases the difference in the extent and seriousness of erosion between the two areas.

Reasons for Greater Soil Erosion

There are a number of physical environmental factors that cause the soil erosion problems to be greater in the southern part of the State. These important factors may be classified under three primary elements of geography, namely (1) weather and climate, (2) soil, and (3) landforms.

Weather and climate. Climate is not only the most important factor in the transformation of regolith into soil, but it is also one of the most important factors in the problems of soil erosion. All other factors being equal, soil erosion increases (a) with an increase in the amount of the thunder-shower rainfall, and (5) with longer periods when the ground is not frozen.

Except for large parts of Franklin, Perry, Washington, Monroe and St. Clair counties which have from 35 to 40 inches of rainfall, the 24 counties to the south get over 40 inches of rainfall with a large part of Union and Pope getting over 45 inches. The 24 counties to the north, on the other hand, get less than 35 inches. In the northern part of the State, moreover, a large per cent of the rainfall is of the cyclonic type. If the ground is not frozen, the slow drizzle characterizing cyclonic rains permits more of the moisture to enter into the ground. If the ground is frozen the run-off does not cause soil erosion.

The heavy, dashing, prolonged rains of southern Illinois in contrast with the cyclonic type to the north bring large volumes of water to the surface causing most of it to run-off. Then, the ground here being frozen for a very short time, the erosion period is longer.

Furthermore, during the winter months the heavy rains in southern Illinois often fall on a thawed surface with the lower part of the soil still frozen thus preventing the water percolating into the ground.[8] Under these conditions, sheet erosion is very effective. Sheet erosion also occurs with continual heavy rains in the late fall and early spring. Winter sheet erosion in northern Illinois is negligible.

Soil. In explaining the wider distribution and greater destruction by soil erosion in the southern part of the State, soil characteristics are of primary importance. In considering the soil erosion problems three soil characteristics should be borne in mind, namely, depth of soil and subsoil, character of soil, and subsoil permeability.

The depth of the soil and subsoil in part determines the size of the underground reservoir. If the mantle rock is thick and the texture of the soil is such that water can run into the ground readily, then, during prolonged rains a large quantity of water can be held in the underground reservoir. On the other hand, if the mantle rock is shallow, only a small amount of rain can be stored. Consequently, during prolonged rains the water table may approximately coincide with the surface of the earth and additional rainfall runs off unless it is held by surface features. Southern Illinois not only has large areas with shallow mantle rock, but in some counties barren out-crops are conspicuous features in the landscape. In contrast with this picture, the deep glacial drift in northern Illinois provides an ideal reservoir where a large quantity of water can be stored.

Because of the character of soil, it is possible to have a deep mantle rock and still not have a good underground reservoir. If the soil does not contain an abundance of humus and does not have a good structure, then water cannot seep into the ground rapidly. Therefore, during hard rains a higher per cent of the water runs off than it would if the rain fell upon a porous soil.

The most widely distributed soil in the northern 24 counties belongs to the brown and black group of soils.[4] Since these soils developed under a slough grass or prairie grass vegetation, they are high in humus. Being high in humus they are porous and permit rapid percolation. Consequently, these soils act as "open doors" to the mantle rock reservoirs below.

In contrast with the soil to the north, the two most widely distributed soils in the southern 24 counties belong to the yellow-gray and reddish-yellow groups. The reddish-yellow group developed under forest vegetation and is low in humus. The pore space in this type of soil, therefore, is low and the soil is "tight". Water does not percolate readily into this type of soil.

The other abundant soil in southern Illinois, the yellow-gray group, is more porous but it is underlain with a clay pan which prevents adequate underdrainage.

Subsoil permeability is a very important factor to consider in judging mantle rock as a probable reservoir. The southern 24 counties are found in two subsoil permeability regions, namely, (1) a region of "slow permeability on level areas, and moderate permeability on sloping areas," and (2), a region of "very slow permeability on nearly level, and moderate permeability on sloping topography."[7] In the first region, because of the downward movement of very fine-textured material and its collection in a zone, there has developed a layer of slowly pervious claypan beneath the level land. Beneath nearly all the level areas in the second region, a compact and plastic claypan has formed at a depth of about 18 inches. This slowly permeable stratum seriously interferes with the movement of moisture. Therefore, during heavy or prolonged rains the soil above the claypan is quickly filled with water and the excess must run-off.

The 24 northernmost counties on the other hand, are in two subsoil permeability regions of a different nature: (1) "rapid permeability on level and on sloping topography," and (2) "moderate permeability on nearly level and on sloping topography."[8] Both of these regions are primarily free of clay pans and permit rapid seepage into the mantle rock below.

Landforms. The importance of slope in the problem of soil erosion is well known. Not only does a steep land gradient increase the velocity of the run-off which in turn causes greater destruction, but there is a close correlation between slope and soil types. And since different soils respond differently to surface run-off, slope exerts an indirect as well as direct influence on soil erosion.

In the first part of this paper attention was called to the fact that one-half of the counties having over 75 per cent of their area affected by "serious" and "destructive" erosion contain the most rugged topography in the State. Because the hill region in southern Illinois is conducive to erosion, the Illinois Soil Survey, after studying the present conditions, recommends that "all slopes exceeding about 7 per cent should be in permanent pasture or forest. . . ." Slopes of less than 7 per cent, if tilled, should be farmed on the contour and some kind of vegetation cover left on the land as much of the year as possible to protect it from erosion."[9]

Thus we see that three primary physical features of geography, weather and climate, soil, and landforms play an important part in influencing the distribution and seriousness of soil erosion. In addition to physical causes, man, with many of his well meaning practices, has also accelerated erosion. It is only natural that when the ground was covered with a grass and tree vegetation erosion was negligible. But when man settled in southern Illinois, he could hardly have caused greater erosion had he planned it. He cut down forests and plowed the grass sod under. He brought steep slopes under cultivation. Open cultivated crops of corn, cotton, and sweet potatoes were grown under a one crop system and with the furrows running up the slope rather than against it. Man often burned the vegetation that might have become humus, and he often overgrazed the pastures. Cover crops and green manure crops were not generally grown.

Now that we are acquainted with the physical and cultural causes of soil erosion, a way of reducing and preventing it should be followed. Since

we cannot change the physical environment, man must change his practices so that they will be more in harmony with conditions in nature. Through experimentations, remedial practices of soil erosion such as contour farming, terracing, winter cover crops, etc., should be studied and followed.

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[1] This map is taken from *A National Plan for American Forestry*, p. 375, Senate Document No. 12, First Sessions of the 73rd Congress. Since this map was issued, more detailed research indicates that a revised soil erosion map will be necessary. No revised map has been issued yet. (May 6, 1938.) Such a revised map, when issued, will show more detailed information. The relation of one eroded part of the state to another, however, which is the central theme of this paper, would be approximately the same on the new map.

[2] "Destructively eroded areas are defined by Dr. A. E. Norton, assistant chief of the Illinois State Soil Survey, as 'areas which cannot be cultivated by any practical known means at a profit because they erode faster than it is possible to build the soil up . . .' Dr. Norton defines 'seriously eroded' lands as 'areas which can be cultivated by specialized methods for profit' . . . No doubt, much of it could best be utilized in forests until such a time as there is greater demand for cultivated crops than at present." *A National Plan for American Forestry*, Senate Document No. 12, First Session of the 73rd Congress, p. 374.

[3] Two of these counties are also bound by the Mississippi river. Of the 16 counties having over 75 per cent of their area affected by "serious" and "destructive" erosion, 6 are bound by the Mississippi river.

[4] *A National Plan for American Forestry*, op. cit., Figures obtained from page 375.

[5] Norton, E. A., and others, *Jackson County Soils*. Soils Report No. 55, 1933, p. 20.

[6] Smith, R. S., and others, "Parent Materials, Subsoil Permeability and Surface Character of Illinois Soils," Map in pocket of book entitled, *Surface Character of Illinois Soils*.

[7] Ibid, Map in pocket of book entitled, *Subsoil Permeability of Illinois Soils*.

[8] Ibid.

[9] Ibid. p. 13.

The Lake District of Northeastern Illinois and Southeastern Wisconsin

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The lake district of northeastern Illinois and southeastern Wisconsin is about 12 to 30 miles wide and 70 miles long and trends roughly north and south about 20 miles inland from the Lake Michigan shoreline. Despite the advanced stage of the agricultural occupance of this area, it is one of the most important recreational districts in the Middle West, for within it there are over 150 lakes, the primary focal points for a great number and a great variety of recreational forms and activities. This district may be said to exhibit a "mature" recreational landscape. This maturity is expressed by (1) a complete utilization of the most desirable shore sites, (2) the over-crowding of cottages in less desirable sites, (3) the comparatively small number of hotels and resorts, (4) the growing permanency of land ownership of lakeshore sites, and (5) the growing tendency toward all-year occupance of lakeshore homes.

The lakes of the district are largely of glacial origin occupying drift-blocked, preglacial valleys, valleys lying between marginal moraine ridges, former glacial drainage channels, simple or complex ice-blocked depressions, and depressions in the ground moraine surface. However, the original character of many of the lake basins has been changed by much damming and dredging activity, brought about primarily by the present great demand for more and better cottage sites.

The most valuable type of shoreline is one which rises rather steeply from the water level, thus allowing for a better view, insuring fairly deep water close to shore, and affording better drainage. The character of the offshore bottom, as an adjunct to bathing, is another significant site factor and has determined quite frequently the locations of the larger resorts. The vegetation of the shoreline might also be considered amongst the criteria determining site attractiveness. Certainly a wooded plot, especially if it contains indigenous oak and hickory trees, is most desirable, while an area of coarse marsh grass is least desirable. All of the lakes were naturally stocked with a great variety of fish and although the supply has been greatly depleted, extensive planting has prevented complete fish depopulation. By and large, however, fishing is at present only a minor attraction of the district.

Several situational factors also help determine land values. Among these are (1) ease of access, at one time determined by distance from a railroad and now by distance from a concrete highway, and (2) the proximity of such recreational facilities as golf courses, amusement parks, resorts, riding stables, or scenic areas such as are found in the nearby rough marginal moraines.

This lake district has long been a center of attraction, and as early as 1856 fishermen from Chicago were journeying to Lake Geneva. Since that time there has been a steady growth in the utilization of the area for recreation. This growth was greatly accelerated in the post war period with the common use of the automobile and the improvement of highway facilities. In this latest period nearly every lake, including some only 10 acres in size, was made the scene of active subdividing schemes. These schemes, because of the earlier utilization of the best sites and because of rising land values, have led to the use and overcrowding of fair and poor sites. As a result,

many lakes exploited during the past 20 years are actually surrounded by villages of rather poor summer homes, some of which might actually be considered rural slums.

The summer home or summer cottage is, by all odds, the most important and conspicuous cultural feature of the landscape of the lake district. There are approximately 15,000 of these structures in the region and they vary considerably in their appearance, running the gamut from stately mansions to flimsy four-walled shacks. The most common type of summer home is a rectangular, one-storied, frame building with two or three rooms, partially surrounded by a wide porch. Usually such an average cottage occupies a wooded 60 to 80 foot lot with exclusive lakeshore frontage, has a garage and a short private pier, and is supplied with electricity. Boathouses are generally found associated with the larger and more pretentious summer homes.

In addition to the summer cottage, there are numerous other features and forms which attest to the recreational use of the lake district. Usually the larger lakes have one or two hotel resorts, each with its battery of cottages. At present, the number of resorts, is comparatively small (*ca* 72), emphasizing the fact that this is a mature recreational area—an area with a semi-permanent or summer population, too over-crowded and too accessible to the larger cities to attract visitors from a great distance. Most of the resorts now function by maintaining public bathing beaches and renting boats to week-end visitors. In addition to the resorts, the highways of the area are everywhere with roadside eating houses, taverns, barbecue stands, and dancing pavilions, while every city and village in the region offers many forms of entertainment to visitors and lakeshore residents. Indeed, most of the settlements in the district function chiefly as recreational centers, a fact more easily understood when one realizes that on a summer weekend there are approximately 150,000 outsiders utilizing the area.

Certainly this lake district constitutes one of the most important and valuable recreational assets of the states of Illinois and Wisconsin, and despite the haphazard and sometimes disastrous way in which it has been exploited, still lends itself to further scientific development. Much of the submarginal land in areas of marginal moraines should be restored to woodland. A zoning plan to insure larger lots, better cottages, and more esthetic laying out of subdivisions should be enacted. More scenic drives, river and lake parkways, and public bathing beaches and camping grounds should be planned. And perhaps some thought should be given to controlled suburbanization of the whole district.

The Muskingum Climatic Study

A. D. Cutshall

Valmeyer, Illinois

Historical Development

The Oklahoma Climatic Research Center at Kingfisher, organized in the fall of 1935, was a pioneer in the field of microclimatology. This project comprised approximately 200 stations located about three miles apart in three counties of west-central Oklahoma. It was in operation about 18 months and furnished the data for several scientific papers such as Thornthwaite's "Life History of Rainstorms".[1] It was discontinued in June, 1937.

In February, 1937, plans were begun for establishing a similar, but larger unit in the Muskingum Valley of eastern Ohio. The first station of the new project began reporting the last of April, and all the data received after June 1 is considered satisfactory.

Undoubtedly the individuals in charge of this project had various and sundry reasons for choosing an area in Eastern Ohio. Certainly the associated work already in progress there was a vital factor in the final decision. The Muskingum Conservancy District was then in the process of constructing a series of 14 flood control dams in that drainage basin. There were two permanent Soil Conservation Service Experiment Stations in the area, namely at Zanesville and Coshocton; as well as the State Agriculture Experiment Station at Wooster. Furthermore there were four demonstration projects and several CCC soil erosion camps in operation. All of these agencies were able to give physical, and, in some cases, scientific assistance to the project. Scientifically, southeastern Ohio offered physiographic and climatic phenonoma which were almost a direct antithesis of those experienced in Oklahoma.

Objects of the Study

It is expected that such a detailed climatic study will permit a more accurate determination and give a better understanding of the frequency and intensity of rainstorms in individual areas; and, at the same time, give further information on the areal expanse and movement of individual storms. In this work each rainstorm can be treated as an individual unit and traced in detail across the entire 8,000 square miles of the Muskingum drainage basin.

Also, the hydrologists of the Muskingum Conservancy District are working in close cooperation with the members of the Washington staff of the Conservation Service in developing improved methods of flood forecast. This, of course, suggests a new approach to the problem of flood hazards by studying the characteristics of complete storms through the data obtained by simultaneous observations from numerous, closely-spaced stations.

There is also the problem of soil erosion and the technical people of the Soil Conservation Service are now utilizing this data in studying the rainfall-run-off relationship, thereby giving it a practical application in the field of soil erosion and land utilization. This is in keeping with the policy of the Conservation Service in studying erosion processes and their variation with changing rainfall intensities.

Personnel

This project is under the general supervision of C. W. Thornthwaite, and under the immediate supervision of Leonard B. Corwin, both in the section of Climatic and Physiographic Research, Soil Conservation Service. The project manager, as well as the laboratory supervisors and most of the field supervisors have had geographic or climatic training. The routine laboratory, shop and observation work is done entirely by W.P.A. labor; of course, under the constant supervision of these trained individuals.

It may be assumed that individuals of the caliber found on relief roles would not be suitable for scientific work. However, in most cases, they have proved to be quite satisfactory. Many of the observers became quite competent in a very short time and, generally speaking, have put themselves wholeheartedly into their work, realizing that they are merely a cog in a large scientific wheel. The laboratory workers, too, have turned out some excellent examples of isopleth maps, which were neatly and accurately colored.

Station Location and Equipment

The 500-odd stations are located at the home of the respective observers. Theoretically they were to be four miles apart; however, the final location and distribution was somewhat dependent upon the number and residence location of the available WPA workers.

Each station is equipped with a rain gage, wind tower, and shelter house, the latter containing a minimum thermometer and both a wet and dry bulb psychrometer. The purchase of such a quantity of meteorological apparatus would probably have been the defeat of the project. Therefore, the Service was required to build all but the most technical equipment. For example, the wind towers and shelter houses were constructed entirely by the W.P.A. shop laborers, the shelter houses costing only a mere fraction of what they would command on the market. The total cost of one of these S. C. S. stations was less than 15 per cent of the cost of similar previous installations.

Compilation of Data

Each observer is required to make his wind, temperature, and cloudiness observations and recordings at 30-minute intervals from 7 A. M. to 7 P. M. These are recorded on convenient printed cards and mailed the morning following their completion. The chart on the rain gauge is inspected daily, being removed and mailed each morning following a rain.

Upon receipt of these cards and charts the laboratory workers check them and plot the data for each 30-minute interval on large onion paper base maps of the Muskingum Drainage Area. To avoid confusion each phenonomon is plotted on a separate map. After the plotting is completed the isopleths are drawn and inked, the map smoothly colored, then checked by a supervisor and filed for reference.

Results and Conclusions

This detailed climatic study in conjunction with the work being done in the field of flood control by the Muskingum Conservancy Project has caused this drainage basin to be referred to as the world's greatest hydrographic laboratory. Certainly the climatic study provides observations at more frequent intervals of time and space than is carried on by any other organization, and this procedure may easily give new knowledge concerning some aspects of local meteorology. Undoubtedly this information will prove valuable to anyone working on a geographic problem in eastern Ohio, and it has already created an interest in the area for two or three individuals are now planning to work or are working on Ph.D. dissertations dealing with the Muskingum Valley or some portion of it.

The real value of this study is not due to its continuation over a period of years, but to the obtaining of sufficient simultaneous observations to permit the classification of rainstorms on the basis of their individual characteristics.

In conclusion, I wish to use the words of one of our outstanding physical geographers, Richard J. Russel of Louisiana State University. At the Ann Arbor meeting of the Association of American Geographers he said, "The Muskingum Climatic Project is an outstanding cooperative project in physical geography and the results should justify the expense a thousand times".

[1] *Geog. Rev.*, vol. 27, pp. 92-111, (Jan. 1937).

Municipal Water Supplies of Illinois*

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AN ABSTRACT

The Municipal water supplies of Illinois are obtained from three sources. The northern part of the State obtains its water from deep, bed rock wells, the central part from shallow wells into the glacial drift, while the southern part obtains its supply from surface waters. There are many exceptions in each part of the State.

Northern Illinois. This area extends from the Wisconsin boundary south to an irregular line drawn from Streator east to the Indiana boundary and southwest to where the Des Moines River joins the Mississippi River at Keokuk, Iowa.

Most of the cities in this area obtain water from deep wells drilled into the Ordovician or Cambrian formations. The water obtained is relatively low in mineral content and is almost always cool and pure. Most of the wells are less than 2,000 feet deep.

The biggest problem in this area is lack of volume. If the wells are pumped rapidly the volume of water produced decreases in proportion. As a result many of the larger cities in this area, as for instance, the cities along Lake Michigan, Rock Island and Moline, have had to resort to treated surface water for their municipal supplies. Rockford with a population of 86,000 is the largest city using deep well water. It obtains its supply from wells drilled to a maximum depth of 1,600 feet.

Scattered throughout this region are shallow wells drilled into the glacial drift. These wells serve the smaller cities with water that frequently has a mineral content higher than that of the deep wells. For example the deep wells of Rockford produce water with a mineral content of 323 parts per million while in Poplar Grove nearby the water produced from drift wells has 402 parts per million. Another example is Freeport with water from deep wells having 449 parts per million while Pearl City nearby uses drift water with 538 parts per million.

In some cases the drift wells produce water with less mineral content than the deep wells. This becomes increasingly common the further south in Illinois one goes. For example the drift wells of LaSalle produce water with 550 parts per million, while at Peru, next door, the deep wells produce water with 878 parts per million.

Central Illinois. This area extends southward from the Streator boundary on the north to a line extending roughly east and west through northern Calhoun County, Pana, and Effingham.

Most of the cities in this area obtain water from glacial drift. This drift is an excellent reservoir since it is deep and porous. The wells produce water quite similar in total mineral content to that of many of the northern Illinois drift wells. Drift wells here do not produce sufficient water for the larger cities, so water supply from this source is confined to smaller towns. There are several outstanding exceptions. For instance Peoria uses water from drift wells. These wells are located near the Illinois River. Indirectly some water may come from this source. Champaign-Urbana also uses water from drift wells. In the case of Peoria much of the water used in manufacturing is obtained from the Illinois River. Champaign and Urbana are not manufacturing cities, so do not use large volumes of water. Large cities in this area that are required to use surface water

* The information used in this report was obtained from the Illinois Department of Public Health and the Illinois State Water Survey.

because of insufficient drift water are Bloomington, Quincy, Springfield, Decatur, and Danville.

Even though the drift wells produce water that is low in mineral content, most of the surface water supplies contain even a smaller amount. For example, the water from the drift wells of Normal has a mineral content of 460 parts per million, while the surface water used by Bloomington has a mineral content at 261 parts per million. Another example of this same situation is at Mattoon. Here the mineral content of the water from drift wells is 500 parts per million, while that in Charleston's surface water supply is 281 parts per million.

There are a few deep wells in this middle area but frequently the water produced has a high mineral content. Minonk's deep well produces water containing 2,210 parts per million. Toluca's deep well produces water with a mineral content of 2,006 parts per million.

South Illinois. This area extends southward from the northern Calhoun County, Pana, and Effingham boundary of the Central area, to the southern part of the state. Most of the cities in this area obtain their water supply from surface sources. It is impossible for them to obtain enough water from the drift since in this section the drift is usually thin with very little pore space. For this reason it makes a very poor reservoir for large quantities of water.

The cost of drilling deep wells, and of pumping them after drilling, is prohibitive since in some places the wells would have to be as much as 5,000 feet deep. Water produced from these wells would be highly charged with minerals, and hence, without treatment would be unfit for human use. This then leaves but one satisfactory source of water and that is from the surface of the land. Usually the streams are dammed and a reserve of water obtained in this manner. Since the soil is compact there is little loss of reservoir water excepting by evaporation.

Surface supplies here have the same advantages and disadvantages as are found at other places in Illinois. The advantage is that the water is low in mineral content. At Centralia the surface supply has 178 parts per million and at Carbondale 163 parts per million. The disadvantage is that all surface water must be purified.

Summary

Because of definite physical conditions it is advantageous for northern Illinois to use deep wells, central Illinois to use drift wells, and southern Illinois to use surface water. These regions, in every case, however, have cities using other sources of water.

In the last ten years there has been a tendency for the three regions to develop surface water supplies. This tendency will probably continue as the demand for water in Illinois increases.

Oil Shale and the Petroleum Problem

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The threatening shortage of the oil supply of the United States as shown by increased oil consumption and diminishing reserves, constitutes a serious problem. In 1936 about one billion barrels were consumed, drawn from a reserve of thirteen and a half billion barrels. A consumption of one billion barrels and the addition of only nine hundred million barrels per year as estimated for 1936, represents an alarming shortage. With the yearly increase in consumption the reserves are inadequate. One solution of the problem lies in the utilization of oil shale of which the United States has enormous deposits west of the Appalachians and in Colorado, Wyoming and Utah.

An oil shale is a bituminous rock containing kerogen. Kerogen is a mixture of hydrocarbons not identical with the petroleum series. It must be processed to obtain the crude oil. Crushing prepares it for the retorts in which distillation takes place. The crude oil distilled from shale is more difficult to refine than petroleum crude for it contains a greater percentage of substances that must be removed. Each shale presents a different refining problem.

Shale oil has been used as a petroleum substitute in many countries, but competition with low petroleum prices has made government protection necessary. The Scottish product is aided by a tax on foreign gasoline and oil. The Esthonian government operates successfully a large shale plant by forbidding the importation of foreign fuel. By making use of a very economical process and cheap labor, Japan is extracting fuel for her navy from Manchurian deposits. With the application of sanctions during the Ethiopian war, Italy resumed distillation of shales in Sicily. The development of oil shales at this time by these nations is a result of their desire for economic independence.

However, in the United States shale oil must compete with very cheap petroleum. The high cost of shale oil is due to comparatively expensive processing costs which produce at present a slightly inferior oil. Competition must await a rise in petroleum prices, a time that now seems remote. Even then, oil shale may not be the substitute. Gasoline has been made by pressure cracking of coal-tar and by hydrogenation of coal. If these processes prove commercially satisfactory, the long-established coal industry may offer a more efficient and economical substitute.

PAPERS IN GEOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The Geology Section carried thirteen papers, of which seven are herewith published. The other six were:

Surface Geology of the Carbondale Quadrangle, by J. E. Lamar, State Geological Survey, Urbana.

Surface Geology of the Alto Pass Quadrangle, by George E. Ekblaw, State Geological Survey, Urbana.

The Undeveloped Coal Resources of Southern Illinois, by Gilbert H. Cady, State Geological Survey, Urbana.

Improved Projection of Optical Apparatus, by T. T. Quirke, University of Illinois, Urbana.

The Scenic Geology of the Illinois Ozarks, by S. C. Trigg, Eldorado.

The Subsurface Geology of the Carbondale Region, by L. E. Workman, State Geological Survey, Urbana.

About forty-five attended the meeting.

J. T. Stark, Northwestern University, Evanston, was elected Chairman for the 1939 meeting.

(Signed) CLARENCE BONNELL, *Chairman*

The New Centralia Oil Field[1]

Alfred H. Bell[2]

Introduction

The New Centralia oil field is of special interest at this time for several reasons. (1) It is being drilled more rapidly than any other field in the State. (2) Geologically, it is located along a well-known line of structural disturbance—the DuQuoin-Centralia monocline—and the new well data are revealing that the structure of the Chester strata differs considerably from that of the Pennsylvanian strata. (3) Economically, the rapid additions by this field to the daily production of the State have resulted in a critical condition of the oil market locally, necessitating curtailment of production by oil buyers in this field.

The writer's purpose in this paper is to describe briefly the development of the New Centralia field and to discuss some of the subsurface geologic features revealed by the new drilling.

Discovery

The discovery well of the New Centralia oil field—the Adams Oil and Gas Company, Schmitz No. 1 well (SE corner, NE ¼, sec. 2, T. 1 N., R. 1 W., Clinton County, Illinois)—was completed November 30, 1937, and was put on production early in December. The initial production was 156 barrels "natural" on the pump from the Benoist sand in the Chester series 1348-1384 feet. This well is located on the northwest flank of a small closure on Coal No. 6, as shown in a map published by the Illinois State Geological Survey in 1927 (Illinois Petroleum No. 10). The Adams Oil and Gas Company made seismograph investigations in the area before choosing the location of the successful test well.

Development Up to April 29, 1938

The rapidly increasing drilling activity in the New Centralia field during the past five months is shown in the following table:

Date	Producing wells	Dry* holes	Drilling wells†	Rigging up	New locations
December 1	1	0	0	0	0
January 1	2	0	0	0	0
February 1	5	0	4	1	5
March 1	12	0	13	16	3
April 5	64	0	56	16	3
April 29	102	2	92	14	5

† Includes drilling wells shut down.
* Within ½ mile of producing wells.

The wells are drilled with rotary tools and 6⅝-inch casing is set on top of the Benoist sand and cemented. Average depth to top of Benoist is approximately 1,350 feet. The "pay" or oil-saturated sand is usually from 20 to 30 feet thick. A small shot of nitroglycerine (usually 10 qts.) is used in most of the wells. Initial production varies from 150 to 500 barrels.

[1] Published with the permission of the Chief, Illinois State Geological Survey.
[2] Geologist and Head of the Oil and Gas Division, Illinois State Geological Survey.

Up to April 29, 1938, the New Centralia field has yielded 264,000 barrels of oil. On April 19 the daily production of the field had risen to 6,200 barrels or an average per well of approximately 62 barrels daily. On April 20, production was ordered curtailed to 20 barrels per well by the pipe line companies because the storage was full at the refineries which were taking the oil.

The apparent producing area of the New Centralia field as of April 29 was 1,000 acres of which 840 acres, more or less, are outside the city limits and 160 acres, more or less, inside the city limits. Of the 102 wells producing on that date, 51 were outside the city and 51 inside. Outside the city most of the wells are spaced in a rectangular 10-acre pattern. Inside the city the average spacing was 1 well per 3 acres on April 29 with about 70 operations (including drilling wells, rigs and new locations) which would result in an average spacing of about 1.3 acres per well.

The New Centralia field brings forward in an acute form one of the problems of the oil industry—that of the proper control of well spacing in a townsite development.

Cross-Section

When the discovery well was completed it was at once apparent that the interval from Coal No. 6 to the Benoist sand is much less than anywhere else in the area where the Benoist had been drilled.

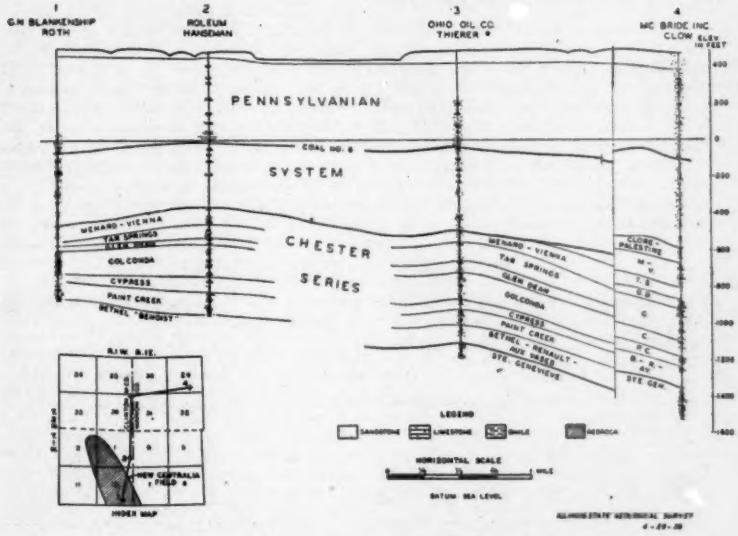

Fig. 1—Cross section in Centralia oil field area.

INTERVAL FROM COAL NO. 6 TO BENOIST SAND

Well	Feet	Increase in interval from Roth well
Adams-Schmitz	853	18
Blankenship-Roth	835	
Roleum-Hanseman	955	120
Ohio-Thierer	990	155
McBride-Clow	1,105	270

An interpretation of the manner in which this interval changes from the central part of the field in a direction north and east is shown in figure 1. According to this interpretation the change in interval is principally due to the absence on top of the structure of some of the formations in the Chester which are present off structure. There is also a marked thinning on structure of several Chester formations as for example the Tar Springs, Golconda and Cypress.

A period of uplift and erosion of post-Chester, pre-Pennsylvanian age in this area is indicated. The present outline of the producing area indicates a trend west of north and east of south for the Benoist sand structure. This trend does not seem to be reflected in the structure of Coal No. 6, in which the principal structural trend—the Centralia monocline and fault—is almost due north and south.

Rotary Drilling in Illinois*

George V. Cohee

Illinois State Geological Survey, Urbana

To the end of 1937 over 20,000 oil wells have been drilled in Illinois, practically all of which have been drilled with churn-drill rigs. The first oil well in Illinois drilled by the rotary method was the discovery well of the Patoka field, completed in January, 1937. Since that date nearly all of the wells in the new fields of the State have been drilled with rotary rigs.

The churn-drill method works on the principle of percussion; a heavy steel bit attached to a manila rope or wire line is raised and dropped about 2 feet on the bottom of the hole to shatter and pulverize the rock. After drilling a few feet the tools are removed from the well and the sludge and cuttings are bailed from the bottom of the hole. The bailer is constructed of pipe, in the lower end of which is a valve that opens by the upward pressure of the fluid passed through as the bailer descends, and closes when the bailer is raised. After all of the cuttings are bailed from the hole the tools are again placed in the hole and drilling is resumed.

The churn-drill method was used by the Chinese centuries before the Christian era. It consisted of a bit suspended from one end of a horizontal cross-pole securely anchored at the other end. Coolies, jumping upon a platform connected to the free end of the cross-pole, provided the motive power for raising the tools which, descending by gravity, deepened the hole.[1] Later came the spring-pole drilling which was used until the latter part of the nineteenth century, and then the power driven churn-drill machines now used.

The first well in Illinois to be drilled by the rotary method was drilled by a portable rotary rig, which had the power and drilling machinery mounted on a large truck. Stationary rotary rigs soon made their appearance in the Patoka, Cisne, and Clay City fields. During 1937, 447 wells were drilled in Illinois and of this number, 285 were drilled with rotary rigs.

In rotary drilling the rock formations being drilled are chipped away by the grinding action of the rotating steel bit. The bit is attached to the bottom of a thick-walled pipe called the "drill stem". The "kelly" or "grief" stem is attached to the upper end of the drill pipe and extends upward through a square hole in the power driven rotary table. It is free to move vertically from a swivel and to rotate with the table while the upper part of the swivel and hoisting block remains stationary. The swivel, kelly stem, and drill stem are hollow, so that the drilling mud may be pumped under high pressure down to and out through holes in the bit. The stream of mud keeps the bit cool, washes the cuttings away from the cones, and carries them upward between the drill stem and the wall of the hole to the surface where they are allowed to settle out in "slush pits". After the cuttings have settled out, the mud is then pumped into the well again. This circulation is continuous as long as drilling is carried on. In addition to carrying the cuttings to the surface, the mud plasters the side of the hole and prevents caving. This is especially necessary while drilling in the Chester series in the Illinois basin. The Chester shales disintegrate when water touches them. In rotary drilling the face of the shale is mudded and does not cave. When drilling through the Chester shales with cable tools, frequently it is necessary to drill a few feet and lower the casing and drill some more in order to prevent serious caving of the hole.

* Published with permission of the Chief, Illinois State Geological Survey, Urbana, Illinois.

Drilling Mud. The physical properties of the mud used in drilling are varied according to the drilling conditions. If the hole caves, a specially prepared clay which forms a gel is added to the drilling mud to make it thicker, more effectively plastering the wall of the hole, so that it will stand up. In most wells drilled so far in Illinois, it has been necessary to use a special mud only to drill through the glacial drift to set the surface pipe. For the rest of the hole the formations drilled through usually contain an abundance of shale and the mud formed weighs from 8 to 10 pounds per gallon. In some wells in the Clay City and Noble fields special mud weighing 10.4 pounds per gallon is used in drilling from the Cypress sandstone to the McClosky sand. This especially heavy mud is used to prevent caving in the Paint Creek shales immediately below the Cypress. The Paint Creek shale causes more difficulty in drilling than any other Chester formation.

Fresh water is used in drilling and the mud remains fresh even though salt water formations are drilled through. As the pressure is very high, the mud enters the pore spaces in sands near the hole sealing off the salt water. Since salt water will flocculate the clay particles, it is important that the salt content of the mud be kept at a minimum.

Adequate Water Supply Necessary for Rotary Drilling. One of the big problems confronting rotary drilling, especially in the summer months, is an adequate water supply. The Diesel drilling rig uses from 500 to 700 barrels of water a day, while the steam rig uses from 800 to 1,400 barrels. It is usually necessary to pump water from a nearby creek or river to have a sufficient quantity of water to supply a number of drilling wells.

Drilling Time. The wells in the Clay City and Noble fields are drilled to a depth of about 3,000 feet. It usually requires from 18 to 21 days to drill a well in these fields to the McClosky "sand". The wells in the Centralia field are drilled in four or five days. The producing formation is the Benoist sand and is reached at a depth of about 1,350 feet. Usually sandstone drills the fastest, then porous limestone, shale and solid limestone in increasing difficulty.

The three-cone type of bit is used in drilling the wells. Each bit costs approximately $100. The average number of bits used in drilling a 3,000 foot hole in the Illinois basin is about 15. However, this number will vary with drilling conditions. In a recent test, drilled a little more than 4,000 feet deep to the St. Peter sandstone, 95 bits were used. The cherty formations of the Devonian system penetrated in this well were especially hard to drill.

The average cost of drilling in the new fields is about four dollars a foot. A completed oil well in the Clay City and Noble field costs from 20 to 25 thousand dollars. In the Centralia field it is from 8 to 9 thousand dollars; this includes the necessary equipment for producing the wells.

Comparison of casing programs for rotary and cable tools. It is necessary to case off the water sands before drilling deeper, using cable tools, because deeper oil sands may be flooded. The hydrostatic pressure of the column of water above the sand may be sufficiently high to force the oil back into the formation. In the discovery wells of the Cisne and Clay City fields a number of strings of casing were run in order to shut off salt water from sands passed through in drilling to the oil sand.

The amount of casing used in the discovery well of the Cisne field is as follows: 44 feet of 20-inch casing; 447 feet of 16-inch; 1,065 feet of 13-inch; 2,142 feet of 10¾-inch; 2,877 feet of 8⅝-inch; 2,942 feet of 5⅝-inch.

With rotary drilling only two strings of casing are used. In the Clay City and Noble fields, the well is drilled to a depth of about 200 feet and 10-inch casing is run to this depth and cemented. The well is then drilled to the bottom of the pay sand with open hole. If the well will make a producer, 7-inch casing is run to the top of the sand and cemented. After the cement has set and the concrete plug at the bottom of the hole has been drilled out, the well is usually acidized or shot with nitroglycerin if oil does not flow to the surface. This treatment makes a larger hole and increases the porosity in the sand. If the well then does not flow, a pumping unit which pumps the oil to the surface and into the storage tanks is installed.

ACKNOWLEDGMENT

The writer extends to the representatives of the Pure Oil Company at Olney, Illinois, and the Shell Petroleum Corporation, Centralia, Illinois, appreciation for information regarding drilling in the new fields. The writer also acknowledges the suggestions and criticism of Dr. A. H. Bell, Head of the Oil and Gas Division of the Illinois State Geological Survey, in the preparation of the paper.

[1] Diehl, John C.—Natural Gas Handbook, published by the Metric Metal Works, Erie, Pennsylvania (1927), page 215.

Resins and Waxes in Colorado Coals

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The nature and behavior of resinous substances in the Upper Cretaceous coals of the Anthracite-Crested Butte quadrangles, Colorado, are being investigated by the writer. At present such studies are still in the preliminary stage but certain information has been gathered which may be of interest to students of coal.

In the Anthracite-Crested Butte district all coals below the rank of an anthracite contain small blebs and veinlets of resinous substances. Some of these substances are known to be resins, whereas others have certain properties which distinguish them from resins and are tentatively designated as "waxes."

Resins appear to be of two varieties, (1) oval-shaped, yellow or orange colored, anisotropic bodies which occur in resinous cells within cellular woody material, and (2) oval-shaped, round or angular masses of canary-yellow color occurring predominantly in the attritus. The former are found chiefly within the anthraxylon in ovaloids 1/100 mm. or less in diameter, but occasionally appear in the attritus. Thus they are distinct from the yellow resins which are strongly anisotropic and appear to be restricted to the attritus. Ordinarily the canary-yellow resins are irregularly distributed throughout the attritus much as are spores and cuticles, but occasionally they are found in zones within the attritus, suggestive of deposition as detrital grains.

Strongly contrasted with the resin cells in the anthraxylon and the canary-yellow bodies of the attritus are other gum-like substances, the "waxes." The former are microscopic in size but waxes range from small bodies less than 1/100 mm. in length to veinlets whose length exceeds 2 cm. The wax varies in color from a light honey-yellow color to a deep brown, and is readily distinguished under the petrographic microscope by its isotropism, in contrast to the anisotropism of the resins.

Waxes appear to have several habits of occurrence. They may occur bedded within the attritus and in such instances appear to be original constituents, since the micro-banded attritus is commonly contorted about the wax bleb. In other cases wax occurs as fillings in cleat fractures, desiccation cracks within the anthraxylon, or not infrequently, filling lumens of plant cells in fusain. The latter cases demonstrate that wax may also be a secondary deposit. Late secondary deposition of waxes was clearly shown in one case where a deposit of calcite and "kaolin" in a cleat fracture formed a crusted vein with the wax. The calcite-"kaolin" deposit lay adjacent to the coal, and the wax had been deposited on the inorganic matter.

Waxes of the yellow, translucent type are extremely soft, having a hardness of 2, and break with conchoidal fracture into a white powder. In ordinary light they have an index of refraction of 1.537 ± 2, and when fresh melt over a temperature range of 193-210°C. A dark brown variety melts at various temperatures ranging from 35°C., for those fragments taken from highly weathered coal, to 180°C. for those waxes taken from seemingly unaltered coal. Except for the great disparity in melting points the brown wax behaves very much like the yellow variety, and a complete gradation seems to exist between the two types. Either kind may occur singly but if the two occur together the yellow variety is always surrounded with brown wax. Likewise brown wax is rarely found without a yellow core.

Weathering alters the brown variety to a dark colored, granular substance, which completely loses its brittleness and becomes a soft powder melting at temperatures as low as 35°C. Such alteration is believed to be largely the result of oxidation, for yellow wax was altered to the brown variety by heating for 15 hours in an oven at a temperature of 130°C., well below the melting temperature of the yellow wax. Heating raised the index of refraction from 1.537 ± 2 to 1.551 ± 2, an increase which is proportional to the darkening of color. Similar results were produced by boiling the waxes five minutes in concentrated nitric acid. Oxidation of waxes within the coal was accomplished by heating polished blocks of coal containing veinlets and lenses of waxes within the attritus. The blocks were heated in an oven for 300 hours at a temperature of 165°C. When placed in the oven all waxes were of honey-yellow color but after eight hours of heating some had already become dark brown. Some waxes within the fissures had shrunk in size, allowing cracks to develop through their center. On the other hand, some of the bedded waxes showed signs of swelling and had burst their way through the block to the polished surface. All such masses of wax were now a brown color. Twenty-four hours after first being placed in the oven the blocks were again removed. Some of the waxes had become so dark as to be nearly indistinguishable from the anthraxylon with which they were closely associated. In other instances honey-colored wax had altered to a powdery dark brown substance apparently identical with that noted in the highly weathered coal. After 300 hours of heating there was practically no further change beyond that of the first 24 hours. The dark material occupying fissures was partly dissipated or highly fractured but a few veinlets of lighter colored wax remained and by swelling had completely separated themselves from the polished block. Swelling seems to be followed in a later stage by marked shrinkage and fissuring of the wax.

The study has not advanced sufficiently to warrant any definite conclusions except that changes in the resins brought about through heating in the laboratory seem to parallel those observed by White[1] to have taken place as the coals approached higher ranks.

[1] White, David, Resins in Paleozoic plants and in coals of high rank: U. S. Geol. Survey, Prof. Pap. 85, p. 69, 1913.

A List of Coal Ball Plants from Calhoun, Richland County

Mary Celestin Fisher[1]

and

A. C. Noé[2]

The coal balls which form the basis of this study were collected in the Calhoun Coal Mine, Richland County, Illinois, under the auspices of the Illinois State Geological Survey. The McLeansboro or Upper Conemaugh, in which geological horizon they were found, is the youngest formation in Illinois and was contemporaneous with the Stephanian of western Europe.

Coal balls are nodules, usually calcareous, sometimes siliceous, found in certain localities in those coal seams which are overlaid by marine deposits. They are often crowded with plant remains of different kinds which have been petrified and so have not undergone carbonization. In order to study microscopically the plant structures found in them it is necessary to make sections of the coal balls. Thin sections may be made by sectioning with a diamond saw and then grinding with carborundum until they are transparent. A simpler method, that of making "peels," has made it possible to avoid some of the labor involved in making thin sections. Peels are made by polishing the cut surface of the coal ball with carborundum and subsequently etching with a weak solution of HCl, which dissolves the inorganic surface material, leaving the organic plant tissue in relief. A thin film of nitrocellulose in butylacetate is poured on the surface. The peel can be removed when dry, which is usually about twenty-four hours later. Subsequent study with the microscope usually reveals nice details of plant structure.

The work of preparing peels of over one hundred and fifty coal balls was done by the authors. The species identified were represented by one, but occasionally by several, of the following structures: petioles, stems, strobili, spores, sporangia, glandular hairs, seeds, and roots.

Explanation of Table

1. Table I indicates the relative frequency of the species identified in the coal balls studied.

(++) Very common
(+) Common
(—) Infrequent

2. The numbers of the coal balls, as given in the table, refer to those in the University of Chicago paleobotany collection.

3. The table also indicates which of the specimens identified are listed in Koopman's Monograph (14) on the coal balls of the Netherlands.

4. This American material is correlated with genera and species in Hirmer's study (9). Specimens included which are identical as to species with those of Hirmer's report are indicated with two stars; those which show generic relationship only are indicated with one star.

5. Each species included is followed by a letter in parentheses which indicates the initial of the author who has described or listed the species as occurring in Calhoun coal balls: Crocker (C); Fisher and Noé (FN); Graham (G); Hoskins (H); Reed (R); Steidtmann (S); Underwood (U).

[1] University of Chicago and Calumet High School, Chicago.
[2] University of Chicago.

TABLE I.—FREQUENCY OF SPECIES IDENTIFIED IN COAL BALLS FROM CALHOUN, RICHLAND COUNTY, ILLINOIS

	Frequency	Serial Number of Calhoun Coal Ball in University of Chicago Collection			Holland (Koopman's Study)	Correlation with Hirmer's Study						
						England (Lower Coal Measures)	Fineftau Seam		Donets Coal Seam C_3^3	Katharina Seam		Belgium Petit Buisson
							Belgium	Ruhr District		Aachen	Ruhr District	
	1	2			3				4			
Amyelon radicans Renault (U)	+	123	400		••	••	••	••		••	••	
Anachoropteris clavata Graham		77	44									
Anachoropteris decaisnei Renault (FN)		100										
Anachoropteris involuta Hoskins					•							
Anachoropteris pulchra Corda (FN)		143	376	167	•	•			•		•	
Ankyropteris westphaliensis P. Bertrand (FN)		179			••	••	••	••				
Annularia species (H)												
Bothrodendron mundum Will. (R)					••	••	••	••				
Botryopteris americanum Graham		44										
Botryopteris cf. cylindrica Will. (FN)		53				••	••					
Botryopteris forensis Renault (H & U)	+	95	197	175								
Botryopteris hirsuta Will. (G & H)					••	••	••	••			••	
Botryopteris ramosa Will. (H)		44				••	••	••			••	
Calamites communis Binney (R)	+	128	156	65	••	••	••	••	••		••	
Calamites (Astromyelon) Will. (U)		128			•	•		•			•	
Cardiocarpus spinatus Graham		44			•	•						
Conostoma platyspermum Graham		501	516		•	•		•				
Conostoma quadratum Graham		517	519									
Cyathotrachus bulbaceous Graham		535	541									
Etapteris lacattei P. Bertrand (FN)		180			•		•				•	
Etapteris scotti P. Bertrand (F)		179										
Heterangium species (F)		179			•	•					•	
Heterangium grievii Will. (U)												
Heterangium tilioides Will. (G)		44										
Heterangium root (H)	+											
Lepidocarpon lomaxi Scott (FN)		187			••		••					
Lepidodendron selaginoides Stern. (G)		171	C225		•	•	•	•			•	
Lepidodendron leaves (G)	+		C225									
Lepidostrobus species (G)		103	104		•	•	•	•	•		•	
Lyginopteris species (R)					•	•		•	•	•	•	
Mascocarpon shorense Benson (G)		44			••	••					••	
Medullosa anglica Scott (FN)	++	146	183		••	••	••	••				

TABLE I—SPECIES IN CALHOUN COAL BALLS—*Continued*

	Frequency	Serial Number of Calhoun Coal Ball in University of Chicago Collection			Holland (Koopman's Study)	Correlation with Hirmer's Study							
						England (Lower Coal Measures)	Finefrau seam		Donets Coal Seam C_2^3	Katharina seam		Belgium Petit Buisson
							Belgium	Ruhr District		Aachen	Ruhr District	
	1	2			3				4			
Medullosa species. Root (H)	+	86	375	110								
Medullosa species. Leaves (FN)	+	91	58	92								
Medullosa noei Steidtman	+	86	375	110								
Myeloxylon species (G)	++	123	91	170	•			•	•		•	
Notoschizeae robusta Graham	—	549	553									
Pecopteris species (U)	—	•										
Psaronius illinoensis Hoskins	—											
Psaronius species. Stem (G)	—	C222	44		•	•	•					
Psaronius species. Root (U)	++	156	41	61								
Psaronius species. Rootlet (U)	—											
Scolecopteris latifolia (G)	—	542	544									
Scolecopteris minor (H)	—	C210	C211B									
Sigillaria cf. approximata Fontaine & White (G)	—	44										
Sigillaria elegans Kidson (FN)	—	113										
Sphaerostoma ovale Will. (U)	—											
Sphenophyllum plurifoliatum Will. & Scott (R)	++	120	145	77	••	••	••	••	••	••	••	
Sporangia cf. Botryopteris (G)	—	44			••							
Stigmaria ficoides Sternberg (G)	+	190	394	44	••	••	••	••			••	
Telangium pygmaeum Graham	—	545	548			•						

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Discovery of Sphalerite and Galena near Millbrook, Kendall County*

J. Norman Payne

Illinois State Geological Survey, Urbana, Illinois

Sample cuttings from a well drilled in May 1937, on the Barron farm near Millbrook, in the NE ¼ Sec. 9, T. 36 N., R. 6 E., Kendall County, Illinois, (Fig. 1), revealed an abundance of sphalerite and a trace of galena in a weathered portion of the Platteville dolomite directly underlying the glacial drift.

A log of the well from which this material was obtained is given as follows by Mr. B. L. Palmer, well driller of Aurora, Illinois:

Formation	Thickness	Depth
Pleistocene system		
Glacial drift	55	55
Ordovician system		
Galena-Platteville formation		
Hard, Blue dolomite	5	60
Conglomerate, soft, blue, cavey, containing water	2	62
Hard dolomite	18	80

L. E. Workman of the Subsurface Division, Illinois State Geological Survey, describes the mineral-bearing material which occurs between depths 60 and 62 feet as follows:

Mixture: Rounded fragments of dolomite, light gray, fine vesicular, more or less weathered, containing much finely disseminated marcasite, some sphalerite, and a trace of galena; loose, coarse crystals of sphalerite; numerous large, irregular masses of marcasite, apparently replacing plant fragments; sand, coarse, rounded grains with secondary crystalline quartz surfaces.

The bedrock under the glacial drift of this area is shown on the geologic map (Fig. 1). It consists from the top downward of the Maquoketa shale, the Galena-Platteville dolomite, and St. Peter sandstone.

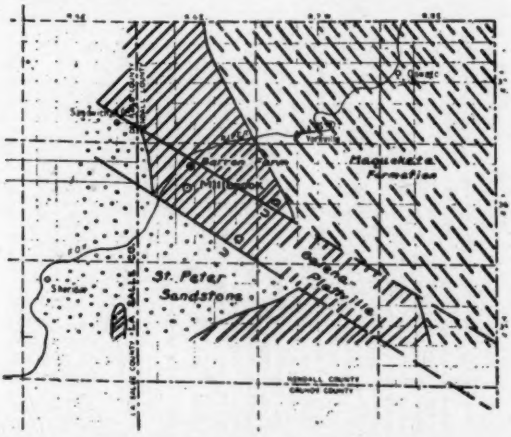

Fig. 1—Geologic map of Millbrook area.

* Printed by permission of the Chief, State Geological Survey, Urbana, Illinois.

The rocks have a general eastward dip. The dominant regional structure is the Kankakee arch, the crest of which is to the southwest of Millbrook. This structure probably had its most important movement in the interval between the deposition of the Shakopee and the St. Peter formations.[1] However, there was some recurrent movement at some time after Maquoketa deposition, as is reflected in the gentle doming evident near Millington, south of Millbrook. It was probably during this post-Maquoketa movement, which possibly may represent relaxational movements after the first intense folding of the LaSalle anticline, that the southeastward-trending fault zone, shown on the map, was developed.

The fault zone is represented by two faults extending in a southeast direction, one through Sandwich and the Barron farm, and the other a parallel fault 3 or 4 miles to the southwest. Very probably other smaller faults connect the major faults.

The sphalerite and galena found in the Barron well are probably a residue from solution in a sinkhole or cavern developed by groundwaters along a fault or in a joint near a fault. If the material occurs in a sink, it is capped by a boulder or overhanging cliff of dolomite encountered at 55 to 60 feet depth in the well. The proximity of the well to the Sandwich fault suggests that the mineralization is related to the faulting. Probably the fault fractures served as channels bearing the mineralizing solutions. Prospecting may reveal other deposits of these minerals.

[1] Ekblaw, G. E., Kankakee Arch in Illinois: Bull. G. S. A. vol. 49, 1938, pp. 1425-1430. Reprinted as Illinois State Geological Survey Circular No. 40.

Subsurface Stratigraphy of Pennsylvanian Formations Associated with Coal No. 6 in the Region of Centralia, Illinois*

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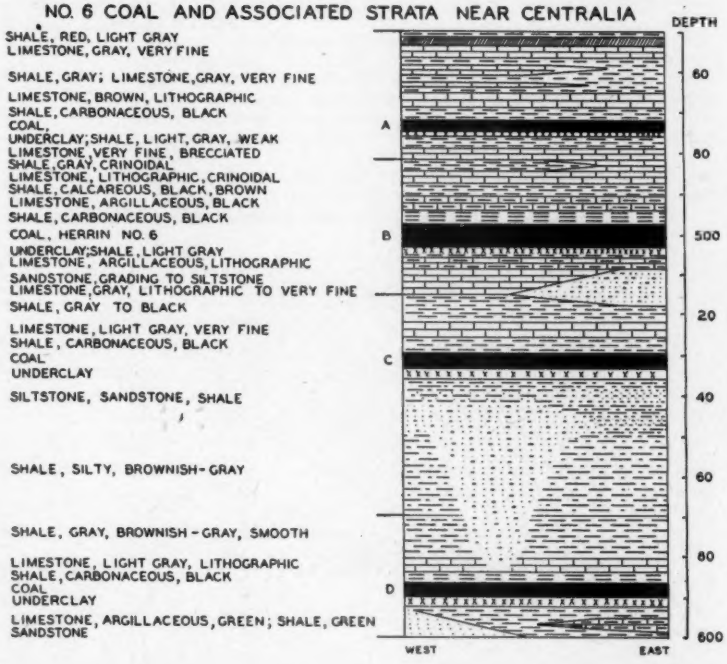
Studies of cuttings from oil wells show a certain succession of strata associated with Coal No. 6 occurring over wide areas in Clinton and western Marion counties and adjacent regions. Because Coal No. 6 is frequently used for structure maps, it may be useful to describe the various elements in this group. The strata comprising a thickness of 150 feet includes four coal seams of which the second from the top is Coal No. 6, well known from mining operations and commonly used for Pennsylvanian structure maps. There are at least four groups of beds, each group containing a coal. The coals are designated as Coal A, Coal B or No. 6, Coal C, and Coal D, respectively, from top to bottom. In making this study data were used from the study of sample cuttings from fifteen wells in the Centralia region, three in the Bartelso field, two in western Clinton County, and four others at intervening locations.

NO. 6 COAL AND ASSOCIATED STRATA NEAR CENTRALIA



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The upper group contain Coal A and extends from a red rock at the top to a brecciated limestone at the bottom. The red rock is a red shale grading to light greenish-gray. Directly below the red rock is a very fine gray limestone, which in some places is cherty, the chert appearing to be a siliceous replacement of the limestone. Under the limestone is a medium gray, slightly calcareous shale which reaches a thickness of about 15 feet in the Centralia region but thins toward the west with an accompanying addition of limestone lenses. The limestone is usually very fine and light gray but is occasionally medium grained with fossil fragments. In the extreme western part of Clinton County it is somewhat dolomitic and the color grades from gray to light brown. Between this limestone and the black shale associated with Coal A is a light to dark brown limestone which is, in most places, lithographic, but is slightly dolomitic in western Clinton County. Overlying Coal A is a highly carbonaceous, very firm black shale which, however, does not have a slaty appearance. The coal is usually only about 2 feet thick. Coal A is followed below by a light gray, weak underclay grading to shale, and a very fine, brownish-gray, partly brecciated limestone.

The beds in the group associated with Coal B or No. 6 may be divided into three parts: 1) The upper shale and limestone, 2) the middle shale, limestone, slate, coal, and underclay, and 3) the limestone and sandstone below the coal. Both the shale and limestone in the upper portion of this group are crinoidal. The shale is calcareous, gray, smooth, and is prominent in all of Clinton County, except the extreme eastern part where it becomes only a thin parting between the limestones. The limestone is light brownish-gray in color with a lithographic to very fine texture. The middle shale is calcareous and gray. It becomes brownish in the western portion and dark gray in the eastern portion of Clinton County. The underlying limestone is a very persistent horizon and is constant as to lithology over a wide area. It is argillaceous, dark brown to black, very fine grained, and contains numerous foraminifera which are white or have a white outline giving the limestone a speckled appearance. Below the limestone is a very carbonaceous, black slaty shale. Coal No. 6 has an average thickness of about 6 feet. It commonly has a blue shale band noted in diamond drill records and outcrop descriptions, but not evident in the sample cuttings. Below the underclay in the lower part of this group is a layer of limestone about 2 to 5 feet thick which is argillaceous, nodular, gray, very fine to lithographic; it is pyritic and sideritic in some places and often brecciated. In the west it thickens and becomes a pure lithograph limestone in the lower part. Below the limestone in western Marion and eastern Clinton counties is a sandstone which grades to siltstone. It is about 10 feet thick in the east but lenses out to the west in western Clinton County. The sandstone is very silty, light gray to gray, very fine, and usually rather compact although it is friable in some localities. The siltstone is either interbedded with the sandstone or completely takes the place of it.

In the group which includes Coal C is a shale and limestone section above the coal with underclay and silty shale to sandstone below. The shale at the top of the group is dark gray to black in eastern Clinton County but grades to a gray shale in the west. Under the shale is a light gray, very fine limestone. In some places these beds have been cut out and are replaced by the sandstone occurring below Coal No. 6. Above Coal C is a carbonaceous black shale similar to the one above Coal A, although in some places it is brownish-gray instead of black. Coal C is commonly two or three feet thick and has an associated underclay. Below the underclay is a gray to brownish-gray, silty, firm shale interbedded with gray, argillaceous siltstone. In central Clinton County this shale and siltstone are represented by a sandstone that occupies the interval to the black shale above Coal D. In the eastern and western parts of the county the imbedded siltstone and sandstone grade downward into a brownish-gray, silty shale.

The last group has at the top a shale, limestone, and sandstone. The upper shale of this group is gray to brownish-gray, smooth and firm, and is not silty as is the overlying shale. Below this shale is a light to medium gray, lithographic to very fine limestone, which is underlain by a carbon-

aceous black shale similar in appearance to that above Coal B or No. 6. Coal D is generally about 3 feet thick; below the coal is an underclay about 2 to 3 feet thick. The underclay grades downward into a weak to firm green shale containing lenses of greenish, argillaceous, lithographic to very fine limestone, which is occasionally quite pyritic. These beds thin and disappear to the west so that the sandstone which is below the limestone and shale is in contact with the underclay. The lower sandstone is silty, light gray, very fine, and compact.

Coal Balls as an Index to the Constitution of Coal*

James M. Schopf

Illinois State Geological Survey, Urbana

The Herrin (No. 6) coal at Nashville in central Washington County is on the whole fairly typical of what is known as "normally banded" bituminous coal. In many places in the mine at Nashville there is in addition an upper bench of coal which on close scrutiny seems to vary considerably from the rest of the bed. The coal is finely striated somewhat like clarain, but is considerably brighter than usual and breaks with a marked conchoidal fracture similar to normal vitrain. It is apparent that this bench of the coal exhibits features commonly given as characteristic for hand specimens of both of these coal constituents. Microscopic observations on thin sections of the top coal reveal that it is composed to a large extent of small vitrainite bands and lenticles. Waxy constituents such as spores and cuticles are rarer than in ordinary clarain and the cell structure is in general more obscure than in the usual vitrainite observed in thin sections of Illinois coals. The coal balls found in this coal at Nashville occur almost exclusively in top coal of this character.

Ever since the important paper by Stopes and Watson, on the "*Origin of Calcareous Concretions in Coal Seams known as Coal Balls*",[1] it has been evident that coal balls are formed *in situ* during the peat stage of coal formation. Thus the organic remains within these concretions may be taken as a sample of the plant material which went into formation of the surrounding coal. In recent years a great deal of attention has been given to study of the constitution of coal by use of thin sections, and etched, relief polished and simply polished coal surfaces. Coal balls, however, have received but very slight attention toward the elucidation of this subject although they would seem to be particularly suited to precise studies relating to the composition of coal seams. The present study is based on analysis of the tissues preserved in the Nashville coal balls.

Seven coal balls ranging in size from one about 18 inches across down to the smallest about 3 inches in diameter were selected from the hundred or so which have been sectioned. Nitrocellulose peels were prepared from the sectioned surfaces and the actual studies made from the peels. One horizontal line and one vertical line were ruled on peels from the smallest coal balls; several lines were ruled in each direction on the larger specimens. Care was taken to space the rulings so each would transect new material with the exception of where the vertical and horizontal lines crossed each other. The selection of coal balls and subsequent ruling was done with knowledge that some rather infrequent forms were present and an attempt was made to include some representation of each of these. A wholly random selection would probably have caused some types of vegetable material to be omitted. It seemed better to avoid this possibility although the percentage of area occupied by the rarer forms is naturally quite small. A glass millimeter rule was laid along the ruled lines and clamped in place with spring clips during each observation. The peels were examined under the low power Greenough type microscope, the plant material transected by the ruled lines was classified and its distance in each case along the line of observation recorded to estimated tenths of a millimeter. Over three meters of coal ball surfaces were measured in this way. Plant entities of the different classes were then totaled and the percentages of each computed. This data is presented in the accompanying block diagram which is

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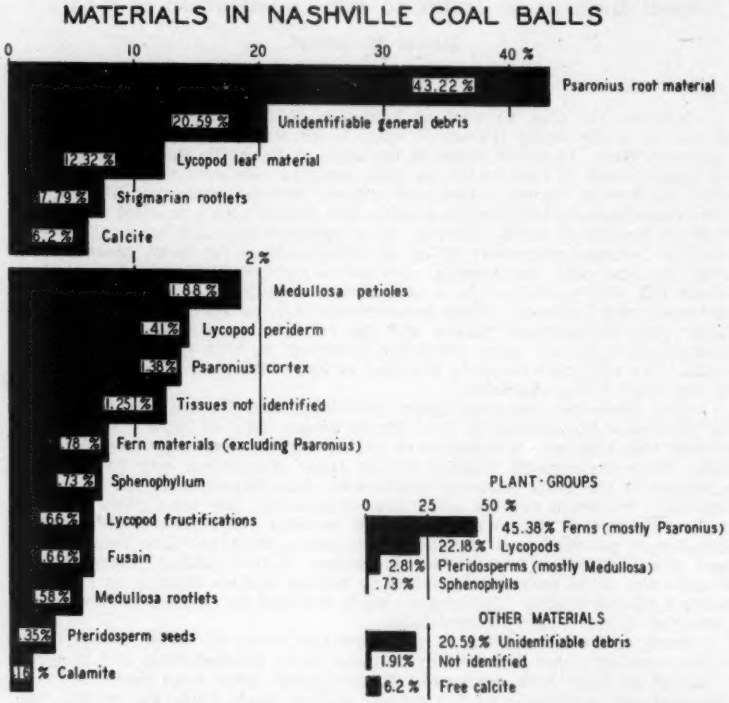
[1] Stopes, M. C. and Watson, D. M. S., Phil. Trans. Roy. Soc. London, B., vol. 200: pp. 167-218, 1909.

largely self explanatory. Percentages of the more infrequent materials (of less than 2 per cent in each case) are blocked in on a larger scale below the 5 more frequent classes. The different plant entitites are combined according to the main groups of plants to which they belong in the smaller diagram at the lower right hand side of the cut.



The most striking thing illustrated by this diagram is the predominance of root material. Rootlets *(Psaronius and Stigmarian)* form 51.01 per cent of the material transected, a far greater percentage than any other individual type of component. The infrequence of woody tissues is also noteworthy and is quite representative of coal balls from this locality. An explanation for the finely striated bright Nashville top coal probably is to be found in the conjunction of these two factors. The rootlets are succulent and composed for the most part of delicate parenchyma cells. The thin-walled cells enclose large air spaces and are very evidently compressible into the characteristic vitrainite strips shown by thin sections from the top coal. These rootlets are lacking in waxy parts such as leaves possess. This, and their manner of introduction into the peat deposit by ramifying growth may account for the dense compact nature of the top coal which gives a good conchoidal fracture similar to that of hand specimens of vitrain.

Unidentifiable general debris is an item of some significance. This material is in the form of disorganized cell and tissue fragments, spores, fusain particles and small masses of humic and waxy material. It bears a strong resemblance to the pulverized residue formed by work of insects in decomposing vegetable matter. No doubt a considerable quantity of this

material enters into the constitution of ordinary coal by filling the interstices. The presence of this material in coal contributes to the difficulty of precisely interpreting microscopic preparations of coal by direct observation. In coal balls this comminuted portion is readily distinguished from the more complete plant parts. The amount of unidentifiable debris may reflect the degree to which decomposition was active during early stages of coal formation.

The plant material in the coal balls has not been subject to a greater degree of packing than is evident in the uppermost layers of a modern peat deposit. Consequently many interstitial spaces are filled with free calcite. Such calcite areas free of plant material amount to 6.2 per cent in the specimens studied. This space would be completely eliminated by compaction later in the coal forming process where calcite concretions were not present.

The unidentifiable debris, lycopod leaf material, *Medullosa* petioles and other minor elements probably contribute in the normal formation of clarain when not effectively dispersed by a preponderance of rootlets. Any large slabs of homogeneous tissue either wood or bark would form a corresponding band of vitrain. As shown by the coal balls most of these latter tissues are too small in the Nashville material to form notable macroscopic bands of this sort. Plant organs composed of heterogeneous tissues such as petioles of *Medullosa* probably never would produce normal vitrain bands although under the microscope the individual tissues would be classifiable as vitrainite.

In general it is evident that tree ferns *(Psaronius)* dominated in formation of the Nashville top coal and Lycopods are probably next in importance. However it is somewhat misleading to assign importance in coal formation to particular plant groups as such. A truer relationship would seem to be manifest between the proportionate amounts of essentially similar tissues supplied for coal formation by various plants of the coal swamp flora. The Nashville coal balls seem to indicate that a large amount of succulent root tissues were included in the top coal and it is very likely that this was influential in determining the character of this particular kind of coal.

PAPERS IN PHYSICS

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Physics Section carried fifteen papers, twelve of which are herewith published. The others were:

Approach to Science via the Survey Course, by G. W. Warner, Wilson Junior College, Chicago.

Scattering of Neutrons by Ortho and Parahydrogen, by J. H. Manley, University of Illinois, Urbana.

Compton Chart of the Electro-Magnetic Radiations, by D. L. Barr, William M. Welch Mfg. Co., Chicago.

Average attendance at the meeting was 40.

A. Frances Johnson, Rockford College, Rockford, Illinois, was elected chairman of the 1939 meeting.

(Signed) R. F. PATON, *Chairman*.

The Use of the Conventional Saw-Tooth Oscillator to Generate Steep Wave Front Impulses

H. A. Brown and P. W. Ryburn

University of Illinois, Urbana, Illinois

Description of apparatus.—The conventional saw-tooth oscillator used to produce a linear time base or sweep voltage for the cathode ray oscilloscope is shown with slight modifications in figure 1. The type 34 tube provides a constant rate of charging the condenser C, and at a critical condenser potential type 885 discharge tube breaks down so that the discharge current from the condenser flows through the plate-cathode circuit of the tube. The

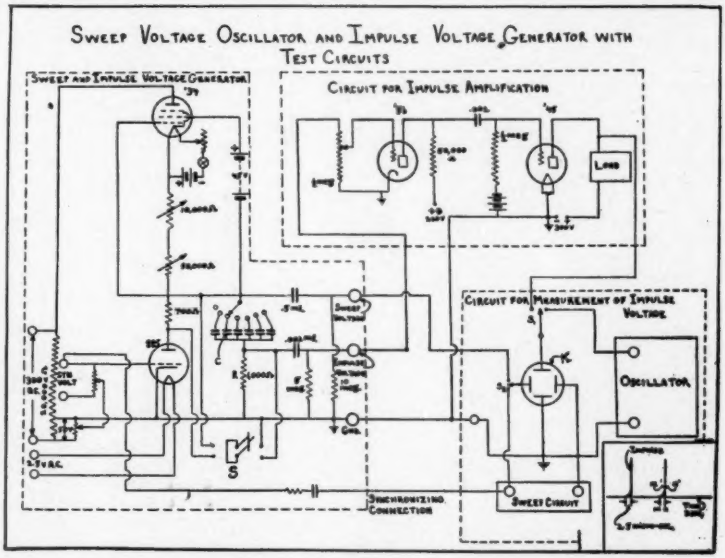


Fig. 1—Conventional saw-tooth oscillator used to produce a linear time base or sweep voltage for the cathode ray oscilloscope, with slight modifications.

switch S is closed to the right when the ordinary sweep voltage output is desired, allowing the 700 ohm limiting resistor in the discharge circuit as shown. When switch S is closed to the left this resistor is short circuited and a 1,000 ohm resistor R is introduced, and the condenser discharge produces an impulse voltage drop across this resistor. There is also a voltage drop across the resistor while the condensers are charging, but this is so small compared to the amplitude of the impulse upon condenser discharge that the former is negligible in comparison. The 0.002 mf. condenser and 5 megohm resistor are connected across the impulse voltage output terminals

for convenient coupling to output circuits such as vacuum tube amplifier grids and so forth. From the impulse voltage terminal connection is made through a potentiometer to an impulse voltage amplifier illustrated in the figure. This impulse amplifier has low value coupling resistors and capacitor, that in the plate circuit of the type 45 power tube being of the order of 1,000 ohms or less. Impulse voltage amplitudes of 150 to 200 volts are thus easily obtained. A cathode-ray tube K is shown in the figure with its vertical deflection plates connected to the amplifier output by means of switch S_1. By means of switch S_2 the horizontal deflection plates can be connected to another sweep circuit shown in the figure so that a pattern of the impulse voltages can be observed on the cathode-ray tube screen.

Impulse voltage pattern.—When the cathode ray tube is used as explained, impulse voltage waves which appear to be simply spaced parallel lines perpendicular to the time base trace are observed. These are illustrated in the small diagram in the lower right-hand corner of the figure. With the impulse voltage generator operating with a saw-tooth wave frequency of 25,000 sweeps per second, the impulses are of course 1/25,000 second apart. The portion mn on the tracing where the beam leaves and returns to the base line was measured and it was found that it could be made as small as approximately 2.5 microseconds. This portion of the impulse can be conveniently eliminated by biasing the type 45 amplifier tube below cutoff, leaving only the vertical line impulse indicated by m'n' and the peak value 0 of the impulse.

In order to determine the space between the impulses switch S_1 is closed to the right, introducing a 1,000 to 10,000 cycle oscillator, and after observing the horizontal distance between the crests of the comparison oscillator voltage wave, and distance between the impulse voltage traces, and hence the time interval, can be very easily estimated. In order to determine the time interval between the start, m', and the finish, n', of the unidirectional steep wave-front impulse, a radio frequency oscillator is substituted for the sweep circuit shown diagrammatically in the lower part of the figure. This oscillator is adjusted until a stationary Lissajoux figure is obtained, after which the time interval is determined from the form of the figure and the measured frequency of the oscillator. This was found to be as low as 1 microsecond.

Application of regularly timed steep wave front impulses.—The useful applications of repeating regularly timed impulse voltages of short duration are many. One of its possibilities is in the study of polarization of a dielectric or in studying the depolarization phenomena. The impulse may be used to shift the grid bias of an amplifier or gaseous discharge tube for a sufficiently short interval to remove the geometric charge on the test electrode plates embracing the dielectric under study, after which the rate at which the charge coming from the dielectric under test may be observed by the resulting pattern on the cathode-ray tube screen. Another possibility is in the study of break-down of air or gases under the influence of impulse voltage, such as are produced by switching, lightening, or other disturbances. This impulse voltage is entirely sufficient to excite a circuit into damped oscillations, and, while the device is not intended to be a transient visualizer, the decaying portion of a transient may be readily observed on the oscilloscope screen by closing S_2 on its upper position, and the sweep voltage will then immediately follow the impulse voltage, giving the transient phenomena pattern upon the screen. This does not show the starting of the transient as does the transient visualizer.[1] Such characteristics as the logarithmic decrement of the damped oscillation and hence of the circuit can be very readily determined by measuring the amplitudes N cycles apart and taking 1/Nth of the natural logarithm of the two amplitudes so measured. In obtaining these decaying transients the circuit being studied is merely connected in the plate circuit of the amplifier tube of either the type 56 or type 45 stages indicated in the diagram.

[1] H J. Reich. "Electronic Transient Visualizers"; Electrical Engineering, Volume 55, No. 12, December, 1936.

Activities of the Amateur Radio Station W9UIH During the 1937 Ohio River Flood

Joseph Dillinger and Frank Green

Southern Illinois State Normal University, Carbondale, Illinois

By way of introduction, a brief resumé of the factors leading to the establishment of the two radio organizations at Southern Illinois State Normal University might be of interest.

In 1934 there were several students on this campus who were interested in amateur radio. After numerous informal discussions of topics of common interest pertaining to the field of radio, they decided that they would like to have a regular meeting place where they could discuss and benefit by the experiences of the others. The physics department was eager to cooperate, and a radio club was soon organized to familiarize students with radio equipment and to give instruction in radio communication. Dr. O. B. Young was chosen sponsor and has served in that capacity since that time.

At first the members of the physics department did not feel justified in requisitioning any equipment for the club. Since this is a nontechnical school, they felt that the interest manifested in this type of work would not warrant the purchasing of radio equipment. However, several of the members possessed amateur operators licenses and had considerable equipment of their own. With various contributions sufficient equipment was accumulated to build a receiver and a small transmitter. A license was then obtained for a station here on the campus with the call letters W9UIH.

Several other students became interested as soon as they came to appreciate the type of work which was being done. The membership of the club increased rapidly, and as a result of that first year of work, eight persons were enabled to pass the examination for an amateur operators license which is given by the Federal Communications Commission.

A year later, in 1935, a bid was received to establish on this campus a chapter of Synton, which is a national radio fraternity. This bid was accepted and Epsilon chapter was established here. Synton had chapters in several of the Big Ten schools, but this was the first Teachers College to be admitted into it. Only those persons who possessed amateur operators licenses were eligible for membership in the fraternity. The members of Synton meet each week to discuss technical problems of common interest in the field of radio.

In view of the interest manifested in this type of work the physics department included in its curriculum a four quarter hour course in radio and requisitioned equipment for the groups. The organization now possesses in addition to testing meters, a National HRO receiver, a 150 watt transmitter on the 160 meter phone band, and there is being constructed a 1,000 watt code transmitter which has modulation equipment capable of 500 watts on phone. The radio frequency final stage consists of two type 852 tubes in push-pull and will be plate modulated, class B by a pair of 203 A's in push-pull.

The advantages of such a set up, particularly in a non-technical school are many. The student, to a considerable extent, masters the field of radio which is a practical application of physics. He learns and better appreciates the fundamentals of the theory courses. He develops manipulative technique and resourcefulness, which lead toward more skillful laboratory and research work. He is made to assume the responsibility of valuable equipment and to operate it in strict compliance with the rules of the Federal Communications Commission.

This type of work here in the past four years has also in many cases led to a vocation and thus has added a skilled worker to the large industrial field of radio. A few of the fellows have gone into radio work as a life's occupation while many others have obtained employment during summer vacations in various radio fields.

Nevertheless, the great opportunity of the radio organizations on the campus to show their importance in a most practical way came during the 1937 Ohio river valley flood. The following messages are typical of those handled by the members of Synton during the 10 days following the break of the flood. "Hello cq cq cq flood traffic cq cq cq Have messages for Shawneetown Stop Water expected to rise 3 feet in the next 24 hours stop Are shipping pump parts requested by air Stop sent 500 cc of antitoxin serum by plane 4:52 this p.m., etc."

At the time of the crisis we had a 70 watt code station in operation of 80 meters, which was soon found to be inadequate to handle the large number of messages received. Two of our men were also operating a transmitter on 160 meter phone elsewhere here in town, but in view of our advantageous location it was decided, on Tuesday at 6:30 p.m. to move their equipment to the radio shack and make it the center of operations. By 10:30 that night all changes had been made and our station was in the midst of flood work. During the following eight days our station was in continuous operation.

Our radio shack was selected as the ideal location for a central station for various reasons. In the first place there were some 700 refugees living in the gymnasiums on the campus. By telephone we were also in direct contact with the Health, Red Cross, and Highway Department offices in Carbondale. Also, the fact that there were several experienced operators on the campus was one of no little importance. At first we had 10 operators, but 3 of them soon left to go down into the flood area to operate portable transmitters. Each operator here had definite hours during the day or night to work, arranged so as not to interfere with his regular program of school work.

Regular schedules at intervals of one or two hours were kept with Shawneetown, Villa Ridge, Paducah, Herrin, Anna, Cairo, and others which were most influential in flood work. One of the three receivers which we had in constant operation was used to monitor WQPD, the police station at DuQuoin. They also had a receiver tuned to our frequency so that we were in direct contact with each other at all times.

During the first two days personal messages poured in from all over the United States. One station alone which we contacted in New Jersey had 25 personal messages to be delivered in southern Illinois and Kentucky. However, the Federal Communications Commission soon banned all personal messages from the air. From then on the majority of messages handled by the station were those from the Health office, Red Cross, Highway Department, and those personal messages involving a situation of life or death.

During the 10 days that the transmitter was in continuous operation, there were approximately 800 messages handled, and this was accomplished through approximately 900 different contacts.

In recognition of the work done by our station we received an invitation to join the Army Amateur Radio System the purpose of which is to establish and have available a system of communication for use in emergencies such as floods, earthquakes, fires, or any other disaster in which commercial communications are out of commission, and where valuable services can be performed by organized amateur radio stations.

We also received a certificate of merit from the American Radio Relay League and a letter of appreciation from the Adjutant General of the State of Indiana.

Fluorescence and Photochemistry of Diacetyl

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Photochemical reactions are chemical reactions which are produced directly, or indirectly, by the absorption of radiation. The most important law in photochemistry is that of Grothus which states that only the radiation which is absorbed is capable of producing chemical reaction. The absorption of the radiation supplies the energy necessary to start the process of chemical reactions. One frequent method for the qualitative study of photochemical reactions has been to radiate with a wavelength which is absorbed and to analyze chemically the end products. However, in order to obtain information concerning the fundamental processes it is necessary to study the material while it is being radiated. This may be done by investigating the fluorescence, when produced, and also by investigating absorption during radiation.

The study of the fluorescence is very useful as it gives a means of investigating various processes which may occur and enter into competition with the fluorescence. Some of the processes are as follows: (1) Dissociation—i.e. the molecule upon becoming excited may dissociate into atoms or radicals. This probability of dissociation depends upon the energy and the lifetime in the excited state. Hence dissociation is a function of the wavelength of the incident radiation and temperature; (2) Collisions of Second Kind—that is, the energy of an excited particle is transferred to another particle by collision. This may mean a loss of electron energy or loss of vibration energy by the excited particle. The number of collisions would be a function of the pressure, i.e., number of particles present; (3) Chemical Reactions—that is, chemical reactions may occur which would not take place between unexcited atoms. Photo-oxidations would be examples of this reaction.

The study of absorption during radiation is very useful as it affords a means of studying the intermediate steps or products of a photochemical reaction. This is important as the intermediate products may exist only a short time. Such would be the case for a photochemical reaction in which free radicals were produced.

Diacetyl vapor absorbs from the blue down to the near ultra violet. Bandedges are found from 4,650 to 4,000 A°U. and the continuum goes down to 3,500 A°U. Fluorescence of diacetyl may be excited by the 4,358, 4,047, 3,650 lines of the mercury arc. The 4,358 line is most efficient. The apparatus used for the production of diacetyl fluorescence was a tube for the diacetyl vapor placed parallel to a mercury arc. Liquid filters were placed between the arc and fluorescing tube to insure monochromatic radiation and also for focussing purposes. The spectral distribution was obtained by the use of a fast Steinheil spectograph. The fluorescence of diacetyl consists of three broad bands, at 5,120 A°, 5,580 A°, 6,100 A°, on which is superimposed some fine structure. This fluorescence has been studied under various conditions; namely, variation of pressure of diacetyl vapor, variation of intensity, and with admixture of oxygen.

The distribution in the spectrum is independent of the pressure in range of .1 mm. to 50 mm. The intensity of the fluorescence is directly proportional to the pressure over the same range. One can interpret this to mean that there is no self-quenching in this pressure range. That is to say, there is no effect of collisions upon the fluorescence which means that the excited particle must be stable against collisions with the unexcited diacetyl molecules.

The intensity of the diacetyl fluorescence has been found to be directly proportional to the intensity of the incident radiation over a five-fold range. For simple interpretation one would say this seems to indicate a single quantum process.

The intensity of the fluorescence is diminished by small amounts of oxygen. The oxygen is consumed upon continued illumination and the fluorescence increases in brightness. Thus one can follow the photo-oxidation by observing the fluorescence. The data obtained for the quenching of the fluorescence by oxygen show that the quenching does not follow the Stern-Vollmer[1] law.

The absorption of diacetyl vapor in the region of the green fluorescence has been investigated during radiation. No change of absorption is detected during the first illumination. However, if the vapor is radiated for a time then left in the dark for a period and then again radiated, marked changes are produced. In a short time after the second radiation begins the absorption reaches a sharp maximum. The absorption immediately decreases to a minimum which is followed by a broad maximum (in time). This maximum is followed by a plateau which precedes the final decay of absorption. A series of products follow one another, as in a radioactive series, the new substances absorbing light of longer wavelength than does diacetyl. The successive transformations are apparently induced by light and the products are detected by changes in the absorption of the vapor.

The purpose of this investigation is to draw from the above experimental facts and others such conclusions as one can concerning the details of the processes following the absorption of light in this molecule.

[1] Physik Zeit. 20, 183 (1919).

A Thermoelectric Method of Measuring Osmotic Pressures

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and

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In 1930 A. V. Hill[1] developed the thermoelectric method of measuring osmotic pressures, using a sensitive thermopile. This method was modified in 1934 by E. J. Baldes[2] who used a single thermocouple. The method so modified and later modifications are the subject of this discussion.

The apparatus consists essentially of a constantan-manganin thermocouple made of wires 0.002 inch in diameter, fashioned into loops (as shown

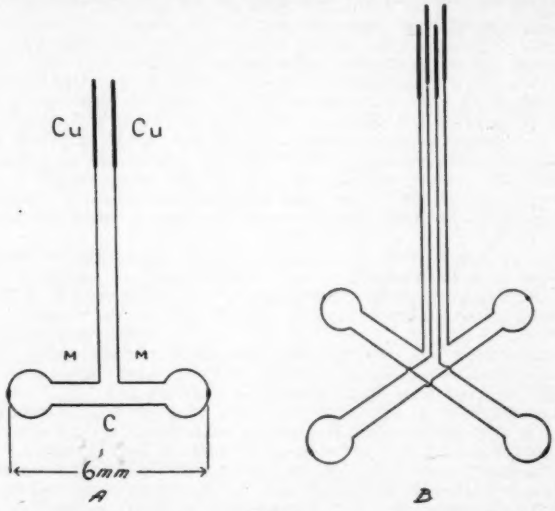

Fig 1

in Fig. 1A) and coated with bakelite varnish. In order to make measurements in duplicate two separate couples are put on one support and enclosed in the same compartment (see Fig. 1B). Either couple may be connected to a galvanometer whose sensitivity is about 10^{-9} ampere.

Small droplets of two solutions whose osmotic pressures are to be compared are placed respectively on the two junctions. The couple is then enclosed in a small water-tight metal chamber the walls of which are covered with filter paper moistened with one of the solutions (see Fig. 2A). The chamber is lowered into a water bath whose temperature is maintained

constant to 0.001°C. If, for example, the vapor pressure of one of the droplets is lower than that of the solution on the walls, vapor from the walls will diffuse to the droplet and condense upon it. The latent heat of vaporization which is liberated will raise the temperature of the droplet and consequently the vapor pressure until there is equilibrium with the solution on the walls. This equilibrium is reached in about 20 minutes. A difference of temperature will thus be maintained between the thermojunctions which will cause a current to flow in the galvanometer-thermocouple circuit. This current will be proportional to the original difference in vapor pressure of the two solutions and likewise to the difference in osmotic pressure.

Since this method has been used most often in physiological measurements, the apparatus is calibrated by using 0.9 per cent and 0.8 per cent solutions of NaCl on the loops and 0.9 per cent NaCl on the walls of the chamber. With these solutions a difference in temperature of about 0.006°C. is maintained between the junctions. The sensitivity of the apparatus is

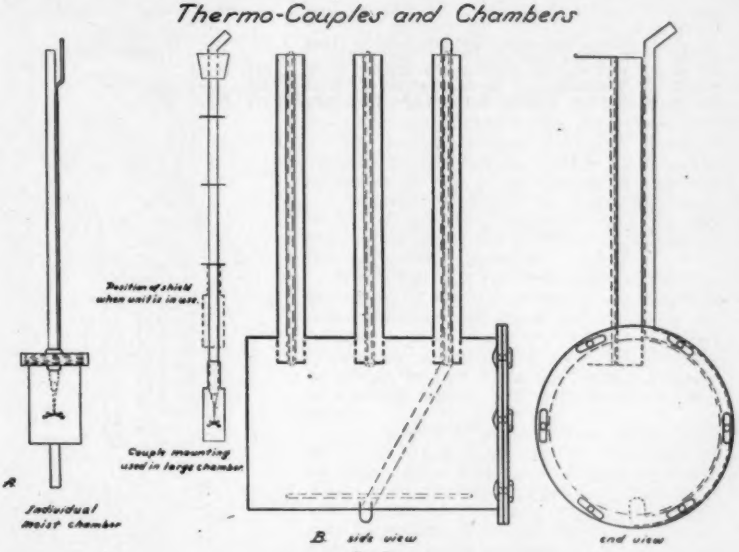

Fig. 2

such that this difference in temperature causes a deflection on the galvanometer scale of at least 50 mm. Thus differences in concentration corresponding to 2 mg of NaCl in 100 gms of water can be detected.

Each thermocouple was found to develop an e.m.f. even when identical solutions were placed upon the two loops. This e.m.f. was usually constant and was allowed for by making two sets of observations in any measurement, the droplets being reversed in the second set. It was found, however, that the above zero e.m.f. is less when the loops are farther removed from the walls. Consequently, the authors had built a large cylindrical brass chamber having a diameter of 6 inches and a length of 12 inches (see Fig. 2B). Three tubes extend from the chamber to a distance of 3 inches above the surface of the water. Three double couples supported by brass rods through which the electrical connections pass are inserted through these tubes into the chamber. The chamber is lined with filter paper moistened with one of the two solutions to be compared and immersed in the water bath. This chamber has proven very satisfactory, giving consistent results.

The zero e.m.f.'s developed in the couples remain nearly constant, the variation of the deflections produced being of the order of 1 mm. The moist filter paper lining remains in good condition, requiring no attention for many days. Three measurements can be made simultaneously and the whole manipulation is simpler than when three individual chambers are used.

Since in the measurement of osmotic pressures of blood it is necessary to make measurements in a mixture of air containing 5 per cent CO_2, tubes are provided in each case for sending such a mixture of gases through the moist chamber.

The accuracy of this method and the possibility of making measurements on small amounts of material at normal physiological temperatures and in an atmosphere of any gas which may be desired, make this method a valuable one in physiological research.[3, 4] Since vapor pressure is considered a significant property of solutions, the method may also prove of value in the investigation of the behavior of solutions in general.[5]

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Visual Lecture Table Methods for Judging the Degree of Exhaustion of a Vacuum Tube

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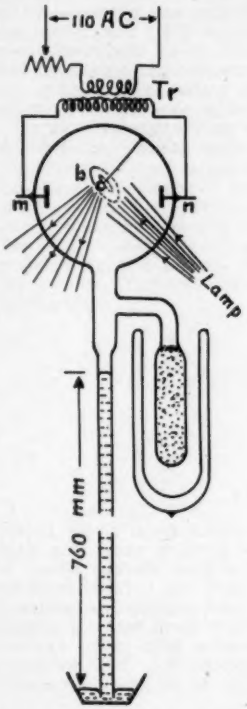

Fig. 1.

The experiment showing the exhaustion of a vessel from atmospheric pressure to, say, 0.001 mm of mercury by means of charcoal and liquid air alone is always interesting and convincing. The degree of exhaustion may be readily shown simultaneously in three separate ways, all *within* the same vessel. These by themselves are *not* new. Two were presented before the Academy by the writer several years ago. The three are:

a) Attach to the discharge vessel a barometric tube set in a dish of mercury, as shown in Fig. 1. As the air is absorbed by the charcoal cooled to the temperature of liquid air the mercury rises in the barometric leg giving a visual indication of the degree of exhaustion.

b) Seal in two electrodes (shown by *m* and *n* in Fig. 1) to which are attached wires from an induction coil, or from the secondary of a small transformer. As the exhaustion proceeds the electric discharge will begin to pass when the Geissler vacuum is reached. This is a very accurate indicator.

c) Mount a small pyrex glass bead delicately on a long slender solid fiber of the same glass within the discharge vessel. When thus mounted (Fig. 1, *b*) the bead will be free to vibrate in any azimuth, and may be set in motion by gently jarring the vessel. When the pressure within is atmospheric the vibrations are soon damped out, however as the pressure is reduced (by the charcoal being cooled to the temperature of liquid air) the vibrations continue for a longer time, and when the vacuum is of the order of 0.001 mm of mercury there is little damping other than that due to the internal friction of the glass can support. The to and fro motions of the glass bead may be seen more clearly, and made visible to an entire class, by reflection of light from a 60- or 100-watt lamp. The bead being spherical its motion may be seen from any angle. For accuracy this device must be calibrated.

The demonstration consists in operating (a), (b) and (c) simultaneously.

Report on the "Flash" in Argon Bulb Prepared in 1931

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That there may be a "flash" in the afterglow of certain gases was shown by the writer about eight years ago. An account of the same was presented before the Academy at its twenty-fifth annual meeting and published in the Transactions of the Academy for the year 1932, p. 173. The initial and practically only bulb (Fig. 1) that still successfully shows this phenomenon was prepared in May, 1931. On two or three later dates an occasional bulb was primed that exhibited flashing but only for a day or two, when this quality would cease. During the second year of A Century of Progress, Chicago, 1934, a 12-liter bulb was exhibited showing the afterglow in nitrogen. After a run of several weeks this began to show flashes, i. e., it flashed

Fig. 1.

for an instant during the period of decay of the illumination of the active-nitrogen afterglow. The writer happened to be present when this flash first became perceptible. In his endeavor to get a more marked effect, by allowing the mechanism that intermittently operated the bulb to continue several hours more, the stem under the exciting coil became hot, softened and was sucked in, thus ending what probably would have been an exceedingly fine prospect,—even better than the 1-liter bulb of May, 1931. Further attempts at the Fair with other bulbs proved unsuccessful. Nor were the experiments at the physics laboratory (University of Illinois) successful either.

Later, during the years 1934 and 1935, the original bulb of 1931 was put through a spectroscopic test, in an endeavor to determine the composition of the residual gas within. The study revealed strong lines due to cyanogen in addition to traces of the more common gases. To check this experimentally pure cyanogen was used in priming a number of bulbs, but wholly without success so far as flashes were concerned. Other gases were also introduced with the cyanogen in varying amounts, all without success.

It thus seems from the observations through these years that the exact surface conditions within the bulb (for it seems to be a surface effect) for marked and permanent flashing are exceedingly difficult to obtain. Even the operator's breath in preparing the bulb may have been a very variable factor too. Nor has the original bulb remained "put". It has changed with

the years. During the first few the flash occurred within a second or two after turning off the current in the energizing coil. Then during the spectroscopic study, referred to above, it was sort of smeared out, beginning a little later, continuing some longer, but decidedly less bright. In fact at times it was doubtful whether there even was a flash. However after periods of six months or more the bulb seemed to regain, in part at least, this property, but never with the same original characteristics. After a rest of over a year (April, 1938) the bulb (Fig. 1) was again subjected to an excitation. This was done last week and to the writer's surprise quite a *marked flash* occurred, however late on the decay curve, some 15 or 20 seconds after the exciting energy was shut off. Only one trial was made at the time for fear that the effect might be "killed" if subsequent excitations followed closely on the heels of this one. Because of the success of this trial it was decided to report the life-history of the bulb to the physics section of the Academy at its May, 1938, meeting at Carbondale. The excitation was carried out in an "inky dark" room, with some misgivings as to its probable outcome. Some of the audience reported a faint flash, others none, others were not sure. The writer from his position at the lecture table (operating the exciting mechanism) also was not sure. Further excitations may have followed but none were conclusive.

The foregoing shows quite conclusively that the ability of the bulb to flash may build up over long periods of time, however that one or two excitations following in close succession (even separated by periods of a few days) seem to remove the possibility of the gas flashing. It also seems quite certain now that the composition of the gas was intrinsically changed during those long periods of excitation at the time of the spectroscopic study. The bulb has practically lost this unique quality; however, the interest in the problem has not waned. It is planned to continue the study with this and other bulbs. The elusiveness of the phenomenon makes the problem the more fascinating.

Optical Rotatory Power of Organic Solutions in an Electric Field*

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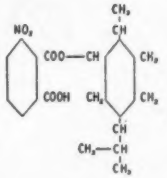
Andrew McLean, a Scotch chemist, has shown that a relationship exists between the rotatory power of an optically active solution and the electron moment of the solvent. It has been found that in general the rotation varies in the opposite sense to the electric moment of the solvent throughout a series of solvents derived from the same parent hydrocarbon. An explanation of this observation has been advanced in terms of dipolar association between solvent and optically active solute and numerous results have been brought forward in support of this hypothesis.

These observations suggested the possibility that an electric moment induced in the solvent molecules by an external E might have an effect similar to that of the permanent moment.

First Experiments.—Previous experience had shown that solvent influences are best observed with optically active components of simple molecular structure with a strongly polar group situated near the asymetric center. For this reason 2l–menthyl–3 nitrohydrogen phthalate was considered a suitable optically active solute.



Since the moment induced in the solvent molecule by an external E is likely to be small compared with that due to the introduction of a polar substituent, it was thought that solvents with zero or very small permanent electric moment would be most advantageous for the proposed investigation. Accordingly benzene and toluene were employed as solvents. Fig. 1 gives the experimental arrangement. We filled the polarimeter tube with a 3 per cent solution of menthylester, applied a field of about 6,000 volts per cm, and rotated the tube through an angle of 180°. Results are shown in Fig. 2 which is a sine curve. Previous observations have shown that the Kerr effect was not present. The Kerr effect is independent of the direction of the electric force and its magnitude is proportional to the square of the electric intensity. Curves in Figs. 3 and 4 show the complicated effect of E. It could not always be repeated. Finally it was found that these solutions had a very slight turbidity. They were filtrated through very fine filter paper and then the effect disappeared completely.

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* Published posthumously. Prof. Kunz died before he could present this paper at the annual meeting. In fact it had not yet been put into typed form at the time of his death. The Academy is honored to publish one of the last works to come from his hand, and hereby acknowledges indebtedness to Prof. J. T. Tykociner for his aid in carrying it through to publication.

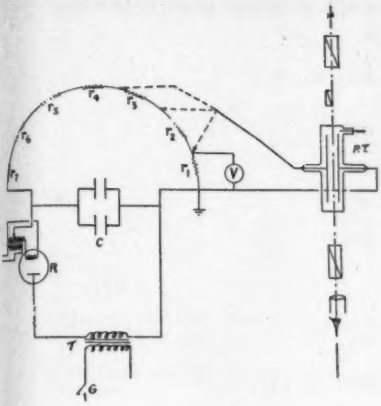

FIG. 1

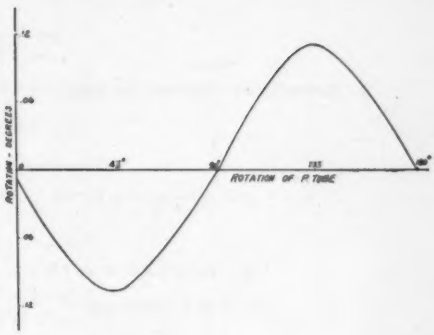

FIG. 2

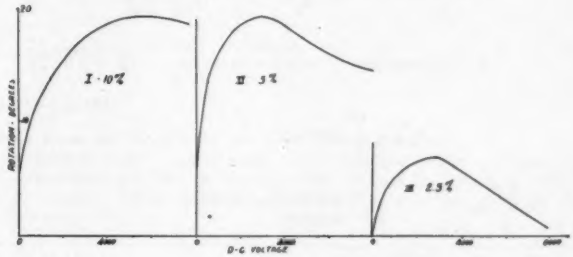

FIG 3

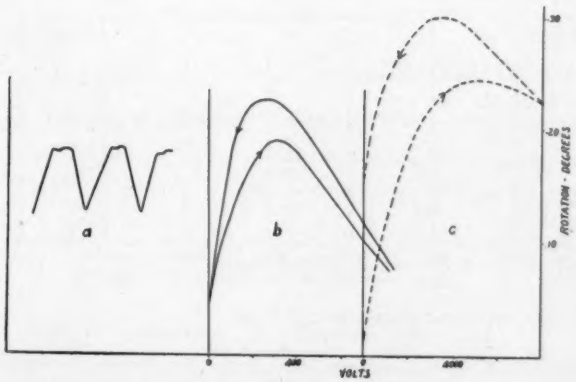

FIG. 4

Theory.—Molecules are either permanently polarized, polar molecules.

$$\mu_T = \frac{F\mu^2}{3kT}$$

or moments are induced by external field.

$$\mu_D = \frac{e^2F}{f}$$

$$\mu = \mu_T + \mu_D = \alpha F = F\left(\alpha_o + \frac{\mu^2}{3kT}\right)$$

$$I = n\mu = n\alpha F = n\alpha\left(E + \frac{4\pi I}{3}\right) \qquad (1)$$

$$D = E + 4\pi I = kE$$

$$I = \frac{D-E}{4\pi} = \frac{E(k-1)}{4\pi} \text{ substitute in (1)}$$

$$\frac{E(k-1)}{4\pi} = n\alpha E\left(1 + \frac{4\pi}{3}\left(\frac{k-1}{4\pi}\right)\right)$$

$$k-1 = n\alpha 4\pi\left(1 + \frac{k-1}{3}\right) = \frac{n\alpha 4\pi}{3}(3 + k - 1)$$

$$= n\alpha\frac{4\pi}{3}(k+2)$$

$$\frac{k-1}{k+2} = \frac{4\pi}{3}n\alpha\left|\frac{M}{\delta}\right. \qquad \begin{matrix} M = \text{molecular weight} \\ \delta = \text{density.} \end{matrix}$$

$$\frac{k-1}{k+2}\frac{M}{\delta} = \frac{4\pi}{3}n\alpha\frac{M}{\delta}\frac{nM}{\delta} = N = 6.06 \cdot 10^{23}$$

$$\frac{k-1}{k+2}\frac{M}{\delta} = \frac{4\pi}{3}\alpha N = P = \text{molecular polarization}$$

for a sphere $\alpha = a^3$, and

$$P = \frac{k-1}{k+2}\frac{M}{\delta} = \frac{4\pi}{3}a^3N = \text{volume of molecules in gm. mol., but in general}$$

$$P = \frac{4\pi}{3}N\left(\alpha_o + \frac{\mu^2}{3kT}\right) \qquad P_o = \frac{4\pi}{3}N\alpha_o$$

$$P - P_o = \frac{4\pi}{3}N\frac{\mu^2}{3kT} \text{ for high frequencies.}$$

the polar part disappears and $k = n^2$ and

$$P_o = \frac{n\pi}{3}N\alpha, \quad \alpha = \frac{3P_o}{4\pi N} \text{ and } P_o = \frac{n^2-1}{n^2+2}\frac{M}{\delta}$$

This determines a, finally

$$\mu = a \cdot F$$

$$F = E \cdot 1.4 \quad E = 66$$

$$F = 93$$

$$\mu = 1.02 \cdot 10^{-18} \cdot 93 = 9.5 \cdot 10^{-22}$$

$$[M] = \frac{M}{100} [a]$$

$$[a] = \frac{a}{l E \delta}$$

$C_6H_5NO_2$: $\mu = 3.89 \cdot 10^{-18}$ $\quad$ C_6H_6 : $\mu = 9.5 \cdot 10^{-22}$

$[M] = 423$ $\quad$ $[M] = 543$

the difference 543—423 = 120 is due to the moment of NO_2 group which is $3.89 \cdot 10^{-18}$

$$120° : 3.89 \cdot 10^{-18} = x° : 9.5 \cdot 10^{-22}$$

$$x = 0.0293 = \text{molecular rotation} = [M]$$

$$[a] = \frac{[M]\,100}{M} = 0.0376$$

$$a = [a]\, l\, E\, \delta = 0.00108°$$

hence our fields were too weak even for E = 20,000 volts/cm.

New Experiments.—The experiment was repeated with stronger A. C. field up to 65,000 volts per cm. A straight line shown in Fig. 5 is obtained according to the theory while the Kerr effect gives a parabola, Fig. 6, which we have obtained for CS_2.

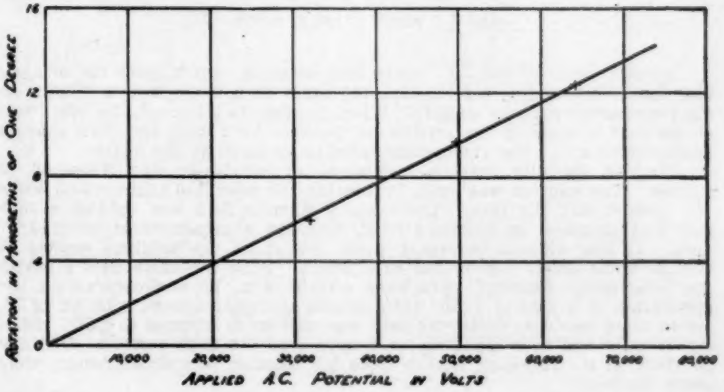

FIG. 5 ROTATION VS. ELECTRIC FIELD

5% SOLUTION OF MENTHYL ESTER-TRI-NITRO PHTHALIC ACID IN BENZENE

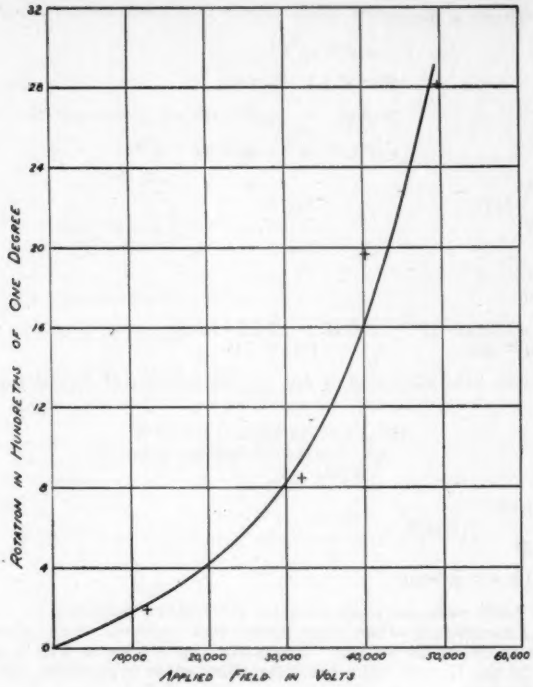

FIG. 6 KERR EFFECT WITH CS_2

Special Observations.—1. After this solution, which gave the straight line, had been standing several days (16 days) then, if the field is thrown on, the polarization changes slightly. When the field is taken off, the other side of the field of sight in the polariscope becomes very dark and then changes gradually to zero. The change amounted to as much as one degree.

2. The optically inactive compound of ethylester was dissolved in toluene. The solution was made by heating the ester and toluene, and while hot, poured into the tube. There again when a field was applied a rotation was obtained, as functions of E, reaching a maximum at about 3,000 volts. It was difficult to repeat these results as the solution seemed to change continuously during the experiment. With the same field strength the polarimeter readings were very erratic, e. g., at one observation the application of a field of 14,300 volts caused an instantaneous rotation of 3°, but in a few seconds, whilst the field was still on, it dropped to 0.35°. After the solution had been standing for 3 days even the most powerful field had no effect on it. However, with a fresh hot solution rotational changes were again observed.

Summary: Various optically active menthyl compounds have been subjected to an electric field. No Kerr effect has been observed. It was found that the rotation of the plane of polarization depends on the angle between that plane and the lines of the external electric field. The rotation of the plane of polarization is a linear function of the field strength in agreement with the developed theory and quite different from the Kerr effect.

Trigger Circuits

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University of Illinois, Urbana, Illinois

Amplifiers in which the direct output current or voltage changes abruptly from one stable value to another stable value at a critical value of direct input voltage or current and changes back abruptly to approximately its original value at a different critical input voltage or current are called "trigger" amplifiers. Trigger circuits are of value in the measurement of short time intervals,[1] in high-speed counting,[2] as the basis of relaxation oscillators,[3] and in numerous other applications.

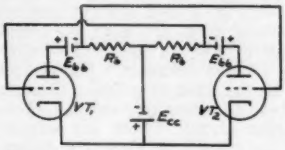

Fig. 1

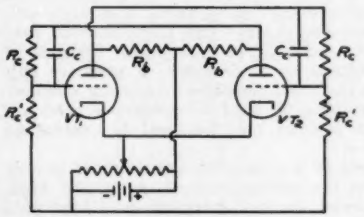

Fig. 2

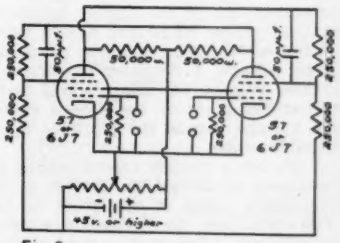

Fig. 3

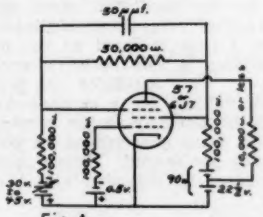

Fig. 4

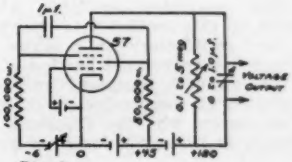

Fig. 5

FIGURE LEGENDS

Fig. 1. Basic form of Eccles-Jordan trigger circuit.
Fig. 2. Practical form of Eccles-Jordan trigger circuit.
Fig. 3. Improved form of Eccles-Jordan circuit using pentodes.
Fig. 4. Trigger circuit using a single pentode.
Fig. 5. Relaxation oscillator for the production of saw-tooth voltages.

The best known type of trigger amplifier using high-vacuum tubes is the Eccles-Jordan circuit,[4] shown in basic form in Fig. 1. This circuit functions by virtue of the fact that only one tube at a time passes plate current. This may be shown by assuming that both tubes carry equal currents. Then any small increase in the current of tube 1 raises the IR drop in its plate resistor, and thus increases the negative grid voltage of tube 2. This in turn reduces the current of tube 2 and hence lowers the negative voltage of the grid of tube 1 and increase its plate current still further. The action is cumulative, the current building up with great rapidity in tube 1 and falling to zero in tube 2. The current can be caused to transfer from tube 1 to tube 2 by applying a negative voltage in series with the grid or plate of tube 1 or a positive voltage in series with the grid or plate of tube 2. The plate current of either tube may be used to operate a relay or other current-controlled device, or the voltage drop in either plate resistor may be applied to the grid of another tube, the plate current of which is used to operate a relay or other device. In practice the circuit is modified so as to require only a single source of voltage, as shown in Fig. 2.

The writer has found that the Eccles-Jordan circuit may be advantageously modified to make use of pentodes, as shown in Fig. 3. The cathodes, plates, and suppressor grids are connected in the same manner as the triode electrodes in the circuit of Fig. 2, and a fixed positive voltage is applied to the screen grids. The control grids are used for tripping the circuit, a negative voltage of half a volt or less on the grid of the conducting tube being sufficient to cause the current to transfer. The circuit is very insensitive to positive voltage applied to the control grids. This lack of response to positive voltage is an advantage in some applications of the circuit.[5]

Another type of trigger circuit which the writer believes to be new is shown in Fig. 4. When the circuit is correctly designed and adjusted, there are two stable values of screen current and two corresponding values of plate current. When the voltages are properly chosen, the plate current corresponding to the higher value of screen current is zero. The plate current increases when the screen current decreases. The plate current may be increased by an increase of negative control-grid voltage, an increase of plate voltage, a decrease of screen voltage, or a decrease of negative suppressor voltage, the control grid being the most sensitive triggering element. Either the plate or the screen current may be used to operate a relay, or the voltage across the plate or screen resistor may be used to control an amplifier tube.

To use a trigger circuit as the basis of a relaxation oscillator it is only necessary to design the circuit so that the abrupt change in current from one stable value to the other is followed by the charging or discharging of a condenser, the voltage of which in turn causes the current to return to its original value at a critical condenser voltage. The multivibrator, based upon the circuit of Fig. 1, and the van der Pol oscillator, based upon the circuit of Fig. 4, are two well-known types of relaxation oscillator. The writer has found that the circuit of Fig. 4 may be used as the basis of another relaxation oscillator, which generates a saw-tooth voltage. The circuit of this oscillator is shown in Fig. 5. This oscillator has proved to be very satisfactory as a source of sweep voltage for a cathode-ray oscillograph. A very small portion of the cycle is taken up in the return sweep of the luminous spot, and no difficulty has been experienced in obtaining oscillation at frequencies up to 20,000 cycles per second. There appears to be no reason why the frequency range cannot be extended into the radio frequencies by proper design of the circuit.

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2. H. Lifschutz and I. A. Getting, R. S. I. *9*, 83 (1938). (With bibliography.)
3. E. W. Herold, Proc. I. R. E. *23*, 1201 (1935). (With bibliography.)
4. W. H. Eccles and F. W. Jordan, Radio Rev. *1*, 143 (1919).
5. H. J. Reich, R. S. I. *9*, (1938).

Secondary Images From Spherical Mirrors

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The ordinary spherical mirrors of the physics laboratory, both concave and convex, usually have plane surfaces in front being silvered on the back curved surface. The front plane surface acting as a plane mirror reflects some of the light coming from the silvered spherical surface back to the silvered surface which in turn reflects it out once more. In this manner an image is formed not only after one reflection but also after three reflections. The secondary images so formed have much less intensity than the primary images but in a well darkened room they are of sufficient intensity that a beginning student might mistake them for primary images.

The formation of these secondary images may be worked out readily as due to a combination of a spherical mirror and a plane mirror. The effective focal length of the combination is equal to one-half the focal length of the spherical mirror alone.

The following figures which are self-explanatory show some of the possibilities of images formed after multiple reflections.

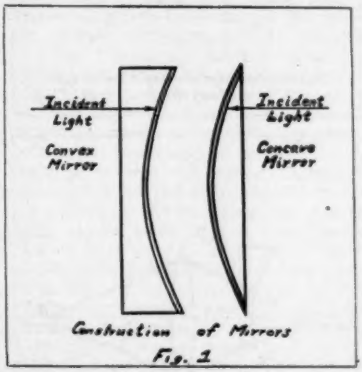


Fig. 1

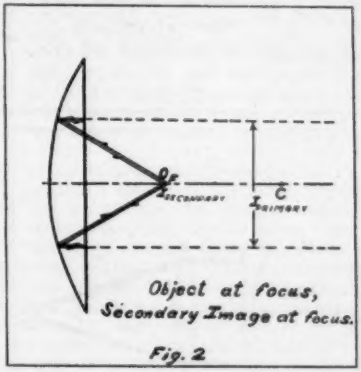


Fig. 2

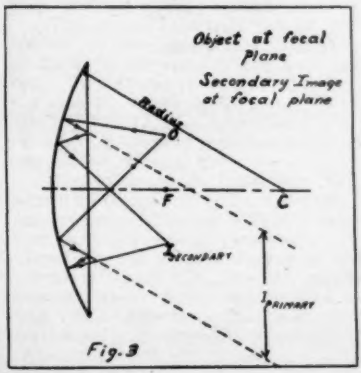


Fig. 3

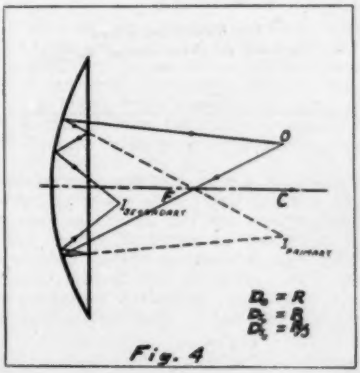
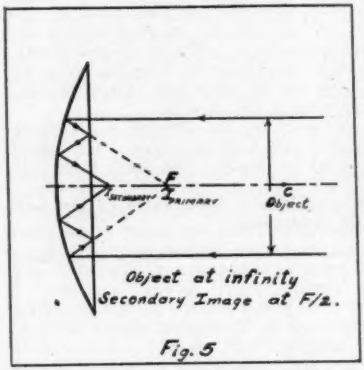
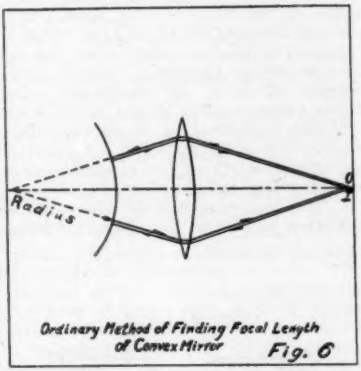


Fig. 4



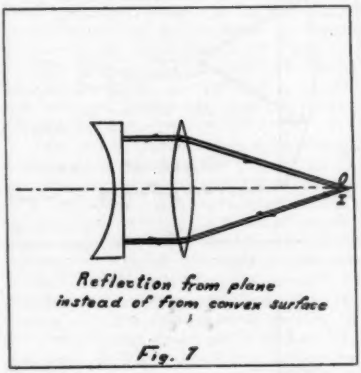
Object at infinity
Secondary Image at F/2.

Fig. 5



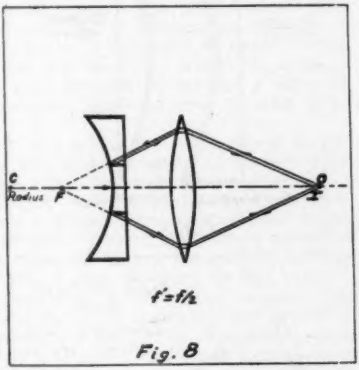
Ordinary Method of Finding Focal Length of Convex Mirror

Fig. 6



Reflection from plane instead of from convex surface

Fig. 7



f'=f/2

Fig. 8

The Scattering of 2.6 Mev Neutrons by Heavy Hydrogen Nuclei

Richard E. Watson

University of Illinois, Urbana

Our understanding of the structure of light nuclei is awaiting further experimental knowledge of the interactions between the nuclear constituents. From recent experimental work[1] on the scattering of neutrons of mean energy 2.6 million electron-volts energy in ordinary hydrogen in a Wilson chamber, conclusions have been drawn regarding the radius and strength of interaction of the neutron with the proton. The experiments show a spherically symmetrical distribution of proton recoils with scattering angle in the center of mass reference system. The neutrons producing the recoils are those of mean energy 2.6 Mev from the deuteron-deuteron reaction. The distribution of proton recoils observed was according to the cosine of the angle of scattering measured. The description of such scattering, the S-scattering, is that only those neutrons have a large probability of being scattered which have no orbital angular momentum about an axis through the protons encountered, i. e., executive head-on collisions.

The interaction between neutron and proton has been successfully described by a pair of potential wells of different depths and widths for the triplet and singlet states in the deuteron. From the S-scattering observed, no test is provided for specific assumptions regarding the character of the n-p force, as to whether it involves an exchange of charge, of spin, or of both, or no exchange at all.

The present experiment on the scattering of neutrons by deuterons was undertaken in the hope that it would provide a check on the symmetry of the forces, in the neutrons and protons, i. e., on whether the neutron-neutron force is the same as the proton-proton force, excepting the Coulomb repulsion of the protons. This would be determined by comparing the distribution of deuteron recoils in the present experiment with the distribution resulting from the scattering of protons by deuterons, provided that the protons were of the same energy, about 2.6 Mev. Another point of interest in the neutron-deuteron scattering is whether it is possible to represent the interaction by a suitable fixed potential hole, or if the deuteron is "polarized" by the incident neutron, so that higher orders of approximation to the nuclear three-body problem are necessary.

The angular distribution of 328 tracks of recoil deuterons has been studied. These tracks have been selected from one thousand tracks measured on 3,000 photographs, which were taken with the aid of an expansion chamber. The chamber was filled with 54.3 per cent deuterium, 37 per cent argon, 6 per cent nitrogen, and 2.7 per cent heavy water vapor; this mixture was bombarded with neutrons of 2.6 Mev energy from the deuteron-deuteron reaction: deuterons plus deuterons give helium three plus neutron plus disintegration energy, Q.

The criterion for selecting the above-mentioned 328 tracks was established by using: (1) the calculated stopping power of the gas mixture, (2) the pressure variation within which tracks can form, (3) the energy-range relationship for deuterons,[2] and (4) the energy variation in the neutrons caused by (a) loss of energy of the incident deuteron beam in the thick heavy-ice target and (b) the angular aperture of the detector. To these selected tracks have been applied the necessary azimuthal, area, and random track corrections, in a manner similar to that used in the study of the scattering of neutrons by protons.[3]

The observed distribution of deuterons, in the laboratory reference system, expressed as per cent number of tracks per unit of solid angle found in each 10° scattering angle interval, is the following: 25 per cent in (0°-9°), 16 per cent in (10°-19°), 12 per cent in (20°-29°), 8 per cent in (30°-39°), 9 per cent in (40°-49°), 12 per cent in (50°-59°), 13 per cent in (60°-69°), 5 per cent in (70°-79°).

Although these results are based on a small number of tracks (328), the data indicate that there is present a marked deviation from spherically symmetrical scattering in the center of mass system. More data are needed to establish the reality of the peak in the curve at scattering angle 60°. Plotted in the center of mass system against the scattering angle in that system, the data seem to follow the curve expected if P-scattering is included, i. e. approximately a quadratic expression in the scattering angle. Such a variation has been found by Massey and Mohr,[4] assuming rectangular potential holes of radii 4×10^{-13} cm and 6×10^{-13} cm, except that the variation of our curve is a much more rapid falling off at small angles, and perhaps a deviation at large angles. The minima of observed and calculated curves coincide with respect to the abscissa. It seems plausible that the choice of a different potential hole, with further regard for the structure of H^2 might allow better agreement with this experiment. The deviation at large angles, if real, would require higher orders of partial waves in the description of the scattered neutron. The deviation at small angles may require for its explanation a potential depending on the polarization of the deuteron by the incident neutron. The polarization potential, superimposed on the fixed potentials assumed for the n-p and n-n interactions, would be slowly varying, acting over longer distances than the ordinary potential. Its effect would be to introduce many spherical harmonics into the description of the scattered neutron wave, which would interfere strongly at the large scattering angles, but would pile up the intensity at the small angles.

An important side result of this investigation is the calculation of the energy of disintegration, Q, of the deuteron-deuteron reaction. The range of a recoil deuteron at 0° scattering angle has been found by "extrapolating" the curves of numbers of tracks against track length along the steepest tangents to the length axis, for the intervals 0°-10°, 0°-20°, 0°-30°. These ranges were reduced to ranges in air under standard conditions through multiplication by the calculated stopping power of the mixture with respect to air. Proper corrections[5] were made for obtaining the mean range, and the range-energy relation for deuterons[6] gave the energy of the deuteron. Considerations of momentum and energy conservation make the disintegration energy Q equal to 3/2 of the energy of the recoil minus ⅓ of the energy of the deuteron beam incident on the target. For the three intervals mentioned, the calculated Q's were 3.39, 3.38, and 3.38 Mev, $\pm$ 0.09 Mev, in good agreement with the result of Bonner,[7] 3.29 ± 0.08 Mev.

FOOTNOTES

[1] The Scattering of Neutrons by Protons, P. Gerald Kruger, W. E. Shoupp, and F. W. Stallmann, Phys. Rev. *52*, 678, 1937.
[2] H. Bethe, Physical Review, *53*, 313, 1938.
[3] Cf. Reference 1.
[4] H. W. S. Massey and C. B. O. Mohr, Roy. Soc. Proc., *146A*, 206, 1935.
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[6] Cf. Reference 2.
[7] T. W. Bonner, Phys. Rev., *53*, 711, 1938.

Single Crystals of Dilute Solid Solutions of Iron in Zinc

H. E. Way, John DeVries and C. L. Furrow

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To Bunker Hill zinc, which is exceptionally pure, was added small known percentages of iron. From these solid solutions single crystals of zinc were grown by the Czochralski-Gomperz method. The growth conditions as a function of percentage of iron present were noted. Previous work[1] has shown that the addition of iron has a peculiar effect upon the micro structure of the pure single zinc crystals. Photomicrographs were prepared of typical samples of various orientations of each concentration of the iron. Lantern slides showing the results of these photographs have also been prepared which correlated with the width of the growth conditions lending additional support to the idea that the iron takes a preferred spot in the zinc lattice. Additional experimentation may give some more definite clue regarding the exact crystalline structure of the compound.

[1] "Micro-Photographs of single crystals of dilute solid solutions in zinc," by Way, H. E., DeVries, John, and Furrow, C. L., Ill. Acad. Sci. *Transactions*, Vol. 30, No. 2, 1938.

One of the Problems of The Air-Conditioning Engineer

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After many years of development, air-conditioning for the home, the office, or the factory is an accepted fact. Within recent years this industry has been expanding rapidly; in the movie, the restaurant, the hotel, the store, the train, the office, the factory, and now in the home. This discussion relates principally to a problem arising from the faulty design and construction of winter air-conditioned homes which is causing much grief and needless expense for the home owner.

By adding special types of heat insulating materials to the outside walls and ceiling or roof structures, and by the use of weather strips, storm windows and doors, and a tighter construction to minimize the infiltration of air, houses are being constructed to better keep the heat out during hot weather and keep it in when outside temperatures are low. Moisture is also added for comfort and health.

A few elementary facts relating to the physics of heat and of water vapor are necessary for a correct understanding of the problem.

Heat tends to flow from higher to lower temperature areas and seek a common temperature level. It does this in one or all of three ways, by radiation, by convection, and by conduction. Suitable types of heat insulating materials tend to impede the flow of heat by conduction and convection, while other types of materials reflect the radiated heat. Loose, fibrous, or granular insulating materials, and such materials in the form of a blanket or insulating board, will impede the flow of heat by conduction and convection, and certain insulating materials having polished surfaces reflect radiated heat as a mirror reflects light.

Air tends to flow from higher to lower pressure areas carrying with it the heat of the agitated air molecules, unless prevented by an effective barrier.

Water vapor, like water, also tends to seek its level and, like water, will flow from higher to lower levels or pressures unless prevented from doing so by an effective barrier.

Many kinds of materials that will prevent the flow of air will not materially impede the flow of heat, and what is even more important, many kinds of materials that act as effective barriers to the flow of air and of heat will not stop the flow of water vapor.

Water vapor is always present in the atmosphere. Room air in a dwelling will usually have a higher vapor content and pressure than the outside air due to evaporation from water pans over radiators and from cooking and body moisture.

Adding heat to air containing water vapor, without the addition of vapor, will reduce the relative humidity. Removing heat will have the opposite effect, increasing the relative humidity until the air has become saturated and its temperature has fallen to the dewpoint temperature. As the temperature is caused to fall below the dewpoint temperature, precipitation of moisture from the air will take place and will continue so long as temperatures below the dewpoint temperature are maintained.

Adding water vapor to unsaturated air without changing the temperature will increase the relative humidity and the dewpoint temperature, and removing it will reduce them.

Air containing a certain amount of water vapor can be brought to the saturation point or 100 per cent relative humidity in either of two ways, by adding water vapor or by reducing the temperature.

When the temperature of water vapor is reduced below the dewpoint temperature, which is the saturation point of 100 per cent relative humidity, condensation and precipitation of moisture takes place. During fairly cold weather some of the materials in wall, ceiling or roof structures will have temperatures below the dewpoint temperature of the inside air. Unfortunately, ordinary construction methods do not prevent the infiltration of moisture through walls and ceilings to those materials having temperatures below the dewpoint where the vapor will be condensed, often forming frost and ice, staining walls and ceilings and causing rot and decay at the same time making relatively ineffective the heat insulating qualities of wall and ceiling materials.

Vapor condensation does not often take place in the walls, ceilings and roof structures of buildings of ordinary construction, having no air conditioning, as the relative humidity of the inside air is usually low, seldom more than 15 per cent in cold weather, and wall and ceiling structures permit leakage of heat that keeps the temperatures of structure materials above the dewpoint temperature, and allows some infiltration of air and ventilation that carries off water vapor that otherwise would be precipitated.

Air at ordinary room temperature of 70° F. and relative humidity of 40 per cent, frequently attained in winter air-conditioning, has a relatively high dewpoint temperature.

Heat insulation added to walls and ceilings of ordinary construction will raise the temperatures of the inside wall and ceiling surfaces and lower the temperatures of the outside surfaces with the result that the dewpoint temperature will often lie within the wall structure and sometimes within the heat insulating material itself with resulting condensation of moisture. A recent experience with this problem will be referred to.

In January of this year one of a number of modern air-conditioned homes in East Lansing, Michigan, built within the last two or three years, was inspected. It was a six room two-story house of wood frame and stucco exterior and wall board and plaster interior, of ordinary construction except for rock wool insulation above the ceilings of the second floor rooms and between the studs of the outside walls. The house was equipped with storm windows and doors and with weather strips, and was tightly and snugly built to prevent the loss of heat from the infiltration of air through walls and window and door frames. Room temperature of 70° F. and relative humidity of 40 per cent were maintained.

But the architect had failed to provide against the flow of water vapor through the wall and ceiling structures into the insulating materials. Condensation was taking place and ceilings of the second floor rooms and the lower parts of the outside walls of the first floor were wet; so wet that the ceilings were warped and sagging and stained, and in places had pulled loose from the ceiling joists. The first floor walls were badly stained. The house was rapidly deteriorating. The owner had complained to the architect who could suggest no remedy.

The situation just described is typical of all too many modern, insulated, air-conditioned homes built in recent years. It represents a problem generally prevalent in the northern states where winters are severe and bring low temperatures of long duration. The subject within the last few years has received considerable attention by investigators of college and other research laboratories, and particularly by Mr. L. V. Teesdale, Senior Engineer of the Forest Products Laboratory of Madison, Wisconsin, in cooperation with the University of Wisconsin.

The solution of the problem appears to be a comparatively simple one; stop the flow of vapor into the walls and ceiling structures. To accomplish satisfactory winter air-conditioning in the homes requires not only that air flow and heat flow be minimized or prevented, but as is evidenced by experiences such as has been described, the vapor flow must be stopped.

This cannot be accomplished with such porous insulating materials as rock wool, mineral wool and other types of loose or packaged insulation or with the various kinds of fibre board insulation.

Reflective insulations represent positive correctives of moisture condensation, and at the same time furnish the necessary resistance to heat leakage and air infiltration. This form of heat insulation can best be applied in the outside walls between the studs and under the attic floor between the ceiling joists.

Where other forms of heat insulations are used it will be necessary to place the vapor seal inside of the heat insulation as near as practicable to the inner wall surfaces. A good grade of building paper will tend to impede the flow of vapor but not nearly so effectively as the reflector types of heat insulation. Vapor which readily flows through ordinary plaster will be retarded somewhat by paint or other like surface treatments. For the homes originally built without special heat insulation and later insulated with rock wool or similar fibrous or granular insulation blown into the walls between the studs and over the ceilings between the ceiling joists, two coats of aluminum paint applied to the inside surfaces of outside walls and ceilings has proven to be most practicable and permits of usual methods of wall decoration.

Experience has not yet shown a perfect vapor seal. Reflective types of insulation seem to be the most nearly perfect. Ventilation of attic and wall spaces outside of the heat insulation should be provided to carry off any vapor that might get through the insulation and otherwise condense, form frost and ice and ultimately cause all of the troubles resulting from a leaky roof.

Heat insulation and air-conditioning are fine, but the effective vapor seal is a necessary concomitant.

PAPERS IN PSYCHOLOGY AND EDUCATION

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The Psychology and Education Sections carried thirteen papers, five of which are herewith published. The others were:

Curriculum Organization and Integration, by J. Monroe Hughes, Northwestern University, Evanston.

The Catholic Method of Integration, by Allen P. Farrel, Loyola University, Chicago.

Educational Integration and Personality Balance, by Ralph W. Pringle, Illinois State Normal University, Normal.

Intelligence Tests as Aids to Educational Integration, by Ralph Yakel, James Millikin University, Decatur.

A Program for the Appraisal of Teaching, by Robert S. Ellwood, Illinois State Normal University, Normal.

The American School Vocabulary, by W. H. Coleman, Shurtleff College, Alton.

Science and Education, by Peter L. Spencer, Claremont Colleges, California, Visiting Professor, Illinois University, Jacksonville.

Reasons Given by Freshmen for Their Choice of a College, by Emma Reinhardt, Eastern State Teachers College, Charleston.

Average attendance at the section meetings was 40.

L. D. Goodfellow, Northwestern University, Evanston, Illinois, was elected Chairman of the 1939 meeting.

(Signed) J. A. MELROSE, *Chairman*

Reading Difficulties of College Freshmen

Howard Bosley

Southern Illinois State Normal University, Carbondale, Illinois

During the fall term at Southern Illinois State Normal University, the freshmen advisers and members of the department of education cooperated in a study of the causes of freshman failure. Diagnostic treatment took several forms, including mental ratings through the use of mental tests, the discovery of personality traits, environmental conditions, the economic situation of the student, the determination of individual effort, aptitudes, and general reading ability. This paper will attempt to present the findings of the reading ability survey.

As a first step in the program, the Iowa Silent Reading Tests, Advanced, were administered to a group of 104 freshmen who stood in the lower deciles of achievement according to marks given in the fall quarter. The results of the tests were shown in Table I.

TABLE I

Test	Test norm.	Class median	No. pupils who equalled or exceeded the norm.	Grade rating of pupils below norm.				
				12	11	10	9	be ow 9th
Test 1. Paragraph meaning	36	26	23	8	17	6	10	40
Test 2. Word recognition (vocabulary)	47	38	7	19	26	26	10	16
Test 3. Paragraph organization	12	7	7	14	13	12	11	49
Test 4. Sentence meaning	30	29	18	18	5	14	7	11
Test 5. Locating information	20	19	40	29	10	12	8	3
Test 6. Rate	31	27	39	2	3	18	19	26

A study of the table reveals the following facts:

1. Most students were low in paragraph reading ability, and very low in organization.
2. Almost half the students knew how to locate information reasonably well.
3. The group was very low in word recognition ability.
4. The rate curve was markedly bi-modal, students tending on the one hand to be moderately rapid to very rapid, or to be very slow, with only a small sprinkling midway between.
5. Sentence reading ability was almost normal, so far as the group was concerned. However, it must be noted that considerable numbers would profit by increased training in this respect.

It was found that a definite positive correlation existed between reading ability and marks in content subjects, as would be expected. A much lower positive correlation existed between reading ability and other subjects, as mathematics, while dependent upon reading ability, draw also upon other major skills.

At this same institution, a college remedial reading class has been set up for those students who desire to improve their reading skills. The class meets once each week, and attempts to assist students to initiate a self help program. Each week attention is called to some new phase of reading, and suggestions are given which assist the student in his attempt to acquire each set of skills. Thus far we have deemed it advisable to stress the following.

1. More voluntary recreational reading. At each meeting several short stories likely to be highly interesting to students are called to their attention. Considerable additional reading is resulting, and students are becoming acquainted with sources heretofore unknown to them.
2. The only request which is made of students other than the suggestion to enjoy the story is that they keep a sharp look-out for new words, and that they attempt to master and use such words in their own writing and speaking.
3. Aside from increasing rate and vocabulary, it is felt that many desirable reading habits and general attitudes are being formed as students of low reading ability engage in such recreational reading.
4. Reading by phrases or thought units.
5. Automatic selection from a sentence or a phrase of those "key" words which are high in meaning content.
6. General comprehension, and skill in dealing with the various types of paragraph material.
7. Skill in the use of the table of contents, the index, etc., in finding information.
8. Skill in organizing the content of reading as a means to thorough learning and better written or oral expression.

It is probable that from kindergarten to college more stress must be placed upon dealing with ideas. The kindergarten child who repeats a story is receiving practice in dealing with sequential thought. Story telling on this level will therefore develop organization skills which will function after the student begins to depend upon the printed page for ideas. All through the pupil's school career, more emphasis must be placed upon the ability to organize.

After the basic reading skills have been formed in the first three or four years of the pupil's school experience, it is probable that there should be little or no formal instruction in reading as a subject course, and much instruction of a more informal nature, utilizing the content matter of regular subjects. This will help to give to reading instruction more vitalized subject matter which has been somewhat lacking hitherto.

The idea of extending reading subject matter to all the subject fields of the school should be carried further into the area of voluntary reading. Many teachers are multiplying many fold the amount of so-called supplementary reading material by encouraging pupils to read newspapers, periodicals and other materials, thus stimulating students to find material intrinsically interesting and forming reading habits and attitudes likely to persist.

Under such a plan of development reading becomes to the child, not another subject with which he must deal but a means to an end—in school and out—a means of acquiring information, and a means of securing wholesome, interesting recreation.

A New Approach to High School Science Teaching

Robert Locke Cooke

Wheaton College, Wheaton, Illinois

Those whose acquaintance with high school science teaching goes back to the comparatively recent period when the high school was primarily for the selected few, will realize that only gradually was it impressed upon teachers and administrators that science teaching would have to undergo considerable modification to meet the changed conditions brought about by the influx of students who were to a large extent not academically minded, and who were not intending to continue their schooling beyond the secondary level. From that time to this we have seen various attempts made to provide a course suitable to such groups, particularly in the science courses of the junior and senior years. Many times we have seen the solution attempted by offering two separate courses, a physics and chemistry "general course" and a somewhat stiffer college preparatory course.

This was surely a step in the right direction, but too often, many will admit, the general course was simply a milk-and-water copy of the regular college preparatory course, a pale imitation which had the justification neither of real value nor of interest. Too often when this was not done, the single courses offered for both groups in junior and senior year science took on much of the nature of the weaker course, with loss to those who needed college preparation, and to the weariness of all.

Many have felt, and rightly I believe, that it would be well to uphold the original high standard for college preparation and to face determinedly the problem of noncollege-preparatory science by attempting to develop a course entirely different, if need be, and really suited to the group for which it is intended. Such an attempt I would call to your attention today, using physics as an illustration. Its practicability has been proved both in actual teaching and in its successful use in teacher-training programs. It will be recognized that if changes are to be made, the problem of both method and content will have to be faced. Turning first to content, the approach may be described briefly.

The idea as worked out for a group of low IQ students in physics, was frankly to abandon the text book, except as desired for reference, and to omit class recitations except for an occasional group gathering when the situation warranted. The key to the situation was in the developing of a set of apparatus which was practically self-teaching, so that by means of brief mimeographed guide-sheets the individuals or groups could proceed in independent order through the larger part of the various standard divisions of the subject, though by no means taking all the traditional subdivisions. To make this material self-teaching, the absolutely essential requirement was to make sure that every piece of apparatus was divested of all its mechanical mystery. This was done by making it either dissectible or glass-enclosed. Sturdiness, full working size if possible, "fool-proofness", and maximum simplicity are the essentials. Whenever possible, though that was not very often, the standard materials supplied for the usual course were used, many times needing modifications however to suit the changed requirements.

Throughout, the emphasis is on stressing the interests of the common man rather than of the research specialist. The result was a course offered in mensuration which by means of a ninety-cent imitation of a surveyor's transit and one or two still simpler devices, rather thoroughly covered the elements of plain surveying; which by means of reclaimed pieces from the nearest automobile wreckers, covered the essentials of the automobile; which by means of a set of "open-faced" panels beginning with the carbon coherer

and proceding through the crystal and one-tube receiver up to a fairly complete transmitter offered a thorough enough course in radio so that only the addition of the code was needed to qualify the student for a government license. Finally by means of a small wind-tunnel and a simple lift-and-drag meter, both built by the school shop, a thorough course in aerodynamics may be developed, including both streamlining and the flying of models.

The total cost of the complete apparatus needed for such a course need not be greater than that of the standard equipment, even if purchased from an apparatus supply house. A considerable number of the pieces may be made by any teacher possessed of a workroom and a little ingenuity.

Only brief mention can be made of a course in chemistry planned along similar lines, emphasizing the practical and industrial features and including many working models of common chemical processes. The possibilities are being developed also in the biological sciences so that there is now no need, where such a program has been worked out, of putting the terminal group in with the college preparatory classes at any stage in their high school science career. Incidentally, it may be added that much if not all of this type of apparatus has been used with great enthusiasm instead of the usual material by college preparatory students working with the standard manuals.

Time will not permit a discussion of the other item mentioned, that of method. Suffice it to suggest that the new approach has seemed best adapted to a rather unique procedure which may be described as a compromise between the teacher-demonstration and the individual laboratory method. This, which might be called the pupil-demonstration method, has been rather completely described elsewhere.

Integration of Subject Matter and Educational Rigor

Robert H. Gault

Northwestern University, Evanston, Illinois

The slant I am taking upon this subject is doubtless different from what you have anticipated. If my course seems strange to you, I remind you that in our formative years as an American people we elected to develop an individualistic society. Such an order of life was growing here during a couple of centuries or more prior to our Revolutionary War. And long before that it had found a hospitable rootage in the minds and hearts of individuals of consequence and in influential groups on the other side of the Atlantic. The individualistic society does not represent a new adventure; not new at any rate, as compared with the span of life of the human individual, but in relation to the range of history since the dawn of what we call our western civilization, this individualistic type of society is a babe in swaddling clothes. We have yet to see what it shall come to be. Thus far, it has made rich contributions for the advantage of us all and for the future its possibilities are great beyond our ability to imagine them.

At the outset I want to affirm my conviction that this type of society bodies forth the highest ideal that was ever invented for men and women who have to live together. All for the individual, not all for the state. The latter, its government, laws and other institutions, are secondary. They are for the convenience of the individual, not to swallow him up. They are his servants. These servants in the individualistic society are here to facilitate the development of the individual toward attainment of the greatest dimensions of which he is capable. The more closely the individual in this society approximates the attainment of his greatest dimensions the less essential these servants become; the bureaus of government and its machinery generally tend to fade away—not to expand to the extent of obscuring the whole landscape. The great individual that is envisaged by the individualistic society gets on with other people with the very minimum of external control and direction. Direction and control by the wholesale from the outside is the very antithesis of the spirit of the pattern of society we have chosen for ourselves.

As a further preliminary, let us take a glimpse at this individual—the focus of our order of life. Those who would substitute a collectivistic order for ours apparently think of him as something small and narrow on the order of the babe in his cradle: an organization of flesh and limber bones and blood with appetites for food, drink, and comfort; an organization that exercises its own natural initiative in various ways as means to obtain satisfaction; that counts as nothing the measure of inconvenience his obtaining these things may occasion to others. As long as these appetites are satisfied, and by whatever means, it's all right with him.

And throughout his life he never loses these natural urges. But he enlarges them and adds diverse other equipments, and the additions are as much a part of his individuality as the original equipments themselves. What are these additions? In general terms, and in a large part, they are techniques, with many of which you are entirely familiar, such as the arts of reading and computation; mathematical and other scientific formulae; methods of investigation, diagnosis in the field of medicine, perhaps, and of the evaluation of evidence. These techniques supply the grooves by way of which the natural personal initiative of the individual may be directed toward the attainment of satisfaction for his innate appetites.

But of course, we have here come very far from listing what enter into the composition of the great individual. One may use the techniques for computation as means for directing natural initiative toward making a livelihood as a bookkeeper or as an expert accountant, according to the pattern of our society or may use the same techniques as means for directing the same initiative toward defrauding an employer in direct violation of our pattern of social behavior.

Something else in individual psychology over and above familiarity with techniques is an effective determiner of the issue between behavior that accords with our social pattern and what is destructive of it. I am thinking here of affective attitudes and I shall attempt to make clear what I mean by that term.

Everyone here, for example, I presume, is affiliated with a political party. How many of you can give me what, in your soberest moment, you would regard as an intelligent answer to my question why you are so affiliated. Probably no one of you can do it. It is most likely just as a matter of course that you are a Republican or a Democrat. You are this or that and there's the end of it. You have a satisfactory feeling: a feeling of all-rightness about your party. You feel quite comfortable and strong because of your affiliation. It is therefore, an easy matter to whip you up to a state of enthusiasm—and you "do your duty at the polls." It is likewise with your religious and your national affiliations. I am speaking here of political, religious, and national attitudes. The quiet sense of satisfaction that saturates them and their matter-of-courseness mark them as affective attitudes. It is probable that you will never quite shake yourself free from them. You may scratch your ticket but it takes a pull to do it. You may in time lapse from your religious attitude, but you can't bring yourself to it at a fell swoop. And as a matter of course you swell with some pride because you are a citizen of your nation. These attitudes grow in the individual from his childhood because he has been all but continuously breathing the atmosphere of the party, the religious organization and the nation. Their leaders have been repeatedly dramatized before his eyes. So have the great ideals of justice and personal integrity, freedom, and philanthropy, that these leaders represented in their lifetimes till what we may call his affective attitudes of justice and integrity and freedom and philanthropy are deep rooted in his make up, and till he perforce lives all these characteristics as a matter of course. His affective attitudes of justice and philanthropy or fair dealing toward the remotest farmer in the realm may be just as inseparable from him as his appetite for food. Such attitudes are the immediate determinants of the question whether one shall as a matter of course employ one's techniques of computation for earning an honest livelihood or for defrauding another.

I repeat that these attitudes are a part of the composition of every individual; certainly of every normal individual. They are as surely a part of him as is his appetite.

And in the next place I want to make a statement that I have not time to develop: your party, religious, national, philanthropic, attitude is a sense of psychologic unity with others who compose the party, who adhere to the same religious organization or the same nation as that to which you profess allegiance or with those who are philanthropic as you are. In a sense of the word the individual with these attitudes is psychologically identified with those others. He and they are a part of each other. Each is a great individual—not necessarily in the sense of a Napoleon. And therein—in this sense of unity—is solidarity and a sense of invincibility. Out of that is cooperation as a matter of course.

It is the genius of the individualistic society to create these great individuals, be they between the plow handles, in the great centers of finance or in the capitol. It has succeeded in such measure that there is encouragement in the belief that it can meet with more success.

These are the individuals who, I have already suggested, minimize rather than magnify the necessity for external direction and control. And now, I am going to assert that it is only in an individualistic society that individuals can attain to the magnificent proportions of which they are capable. The

necessity of such a social order as ours sternly dictates that men and women shall attain these proportions: that they shall acquire the techniques whereby they may control the world and that they shall grow into a sense of psychologic identity or of belonging together with others who cherish the political, national and ethical ideals that are embodied in our patterns of social behavior. When the necessity of the situation makes its demand upon human nature we are on the way toward accomplishment. But we, in our several capacities as leaders, must be vividly conscious that the necessity exists. We dare not just lazily and as a matter of course acknowledge that it is there and let it go at that.

What are we going to do about it? Are we going to organize some new curricula? Laboriously document the content of each course? I once heard President Butler say: "It makes little difference what subjects are taught; it makes some difference how they are taught, but it makes a great deal of difference who teaches them." Already you are prepared for a violent reaction toward my coldness in respect to the organization of curricula and courses of instruction.

I am recalling now two of my teachers: two who have meant more to me than any other two with whom I had to deal in all my school and college and university days,—unless I should except one or two who worked within the field that has become my specialty. One of those was a teacher of Latin in a small Ohio college—William Notestein; the other was a teacher of Shakesperian literature in a great university—Hiram Corson. The latter, at least, qualified as a great scholar and an exact scholar. But they had in common one very important characteristic: they could dramatize their subject—and they dramatized it. The great persons of the drama moved in the midst of our classrooms; the traits of their characters stood in vivid relief before our eyes; they made us tingle with excitement. They contributed toward making and they roused our positive affective reactions toward the great characters in the literature they were teaching. They made us feel that the admirable traits in these characters were ours too. Thus far, between them and us, we began to sense a psychologic identity. Now that kind of thing can't go on long without creating in the pupils a drive toward perfecting in themselves those character traits that the teacher is dramatizing and at the same time toward making them dynamic.

Every good teacher acts upon these suggestions whether he makes an analysis to discover the whys and the wherefores of his procedures or not.

And so I am urging something very old fashioned: not organization or integration of a curriculum. This, I believe, is of secondary importance. Our pupils must acquire facility in the use of the tools by which they may gain some control of their world, to be sure. That is of first rate and immediate importance. And equally important it is that they acquire a great and vigorous individuality. That is what we must emphasize. And this immediately implies a feeling of identity: a sense of belonging together with those characters who have in the past possessed and demonstrated the qualities of benevolence and philanthropy; of honesty and justice and fair dealing; of personal initiative in the ordinary affairs of everyday living, in the affairs of great business and in statecraft; in all the relations of life. And it implies, likewise, a feeling of identity with those who are now, in our American way of life, demonstrating their possession of these qualities of the great individual. It is upon these things that we must have a new and systematic and continuous emphasis in our teaching of literature and history, science and art. We talk about vitalizing the educational process and we soft pedal the means by which it can be accomplished. We talk about socializing education and at the same time we neglect the very essence of socialization. What is it? Once more it is the individual's matter-of-course, satisfying sense of identity with those people who have in the past exhibited, and who are now exhibiting such qualities as I have mentioned: the qualities of the great individual without which social life can never be in flower.

I have now suggested my idea of the integration of subject matter. It must be integrated about what, by common consent, we will regard as the great personal qualities of those whom, again by common consent, we will

call our great men and women. This demands dramatization of those qualities to the end that our pupils may be helped in developing affective attitudes toward them: that they may be warmed by the feeling that these qualities are as a matter of course to be supremely desired: that the people who exhibited them are THE people. Therein is educational rigor from the point of view of the teaching process and from the view point of the finished product. The debunker is a failure as an educator. That great nebulous abstraction, THE STATE, will get along if we attend to the business that is immediately at our hand: making great individuals. And by the same token, it is the first business of the individual to make himself great in the sense I have indicated. Any other emphasis than that makes a hard character; places a limitation upon the development of the individual; maintains him in a diminutive stature and so obstructs the processes of social life.

The Effect of Incidental Factors on Threshold Measurements

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and
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The determination of "limens" or "thresholds" as a measurement of the sensitivity of receptor organs is a corner stone of psychophysics and experimental psychology. This technique is also used to advantage as a diagnostic instrument in clinical work. Not until recent years, however, has much attention been given to the factors affecting the stability of thresholds.

That the vague point in sensory discrimination, termed the "limen", is unstable is not surprising when one considers that its accurate determination depends upon the observer's ability to maintain a constant criterion of sensation throughout the experiment. Even if the observer could meet this requirement, changing conditions in the laboratory and subjective changes in the observer still significantly alter a threshold measurement. Goodfellow[1] has studied some of these factors affecting vibro-tactile thresholds, and he found that thresholds were changed by the following actors: 1. suggestion; 2. psycho-physical technique; 3. motivation; 4. practice or training; 5. the experimenter; 6. instructions to the observers; 7. part of the body stimulated; 8. fatigue of the end-organ due to previous stimulation; 9. long period of sleep immediately before measurement; 10. intense illumination. Ray Mars Simpson[2] enumerates over forty factors involved in measuring sensory thresholds, including such factors as "mental set", "aufgabe", anticipation, motivation, suggestion effects through the experiment criterion of judgment, instructions, and attention.

For some time we suspected that observers, when forced to make discriminations at or slightly below their threshold, did not rely entirely upon the modality being measured but turned to incidental variables in an attempt to gain cues from the environment. To test this possibility, we introduced a known cue into an ostensibly normal set-up for determining thresholds. Our primary concern was the selection of a cue that could be controlled and at the same time was in and of itself least affected by the factors mentioned above. We finally employed time discrimination in the visual "ready" signal because it most nearly approached our criteria for an unaffected cue.

Observers were requested to place their fingers on a vibrator and determine at a given signal whether or not any stimulus was present. As a "ready" signal we used a flashlight bulb placed behind a two-inch square of red paper and situated directly in front of the observer. It was either one second or one and three tenths seconds in duration. The long (1.3 sec.) and short (1 sec.) "ready" signals were used in a random order. Both the "ready" signals and the two-second interval following each stimulus were accurately controlled by mechanical means.

During this particular experiment, the vibrator was completely disconnected from the power supply, in order that we might be absolutely sure that any extra-chance results were due to responses to our differential signal rather than to a subliminal vibratory stimulus. The observers were instructed that the vibrations would be below threshold but that by responding to "hunches" and by careful attention to the vibrating instrument they should be able to achieve better than chance results in determining whether

the vibrator was activated or not. After each appearance of the "ready" signal, the observer was expected to respond "yes" or "no".

During the first half of the experiment, judgments were taken in groups of five, to determine whether any allowance had to be made for a pattern effect similar to that found in the Zenith telepathy data.[3] Each observer recorded his own response on the forms supplied by the experimenter. An analysis of several hundred responses from each of five observers show two pronounced tendencies,[4] namely, a tendency to respond in the negative, and secondly, a tendency to follow certain patterns or sequences. Any tendency to use our extraneous cue was, if it existed, over-shadowed by these two other tendencies.

Consequently, the chief problem seemed to be the elimination or control of these two factors. To accomplish this we changed our instructions and procedure in certain details. First of all, we impressed upon the observers the fact that even though the stimuli were subliminal, they would, by responding to any slight impression or "hunch", be correct more often than not. Furthermore, we reminded our observers that stimuli were presented in chance order, and therefore, there would be approximately an equal number of "yeses" and "noes". These instructions we hoped would reduce the tendency to respond with a preponderance of "noes." By having the observers report their guesses directly to the experimenter over our loudspeaker telephone system, we hoped to minimize the tendency to follow particular patterns or sequences. (We assumed that this observed tendency to follow certain patterns or sequences is due largely to the influence of one's previous responses. By using an oral report, we removed the necessity of having our observer's previous responses called to his attention.) Six observers were used under this new set-up, and the results are shown in table one.

TABLE I

Table showing the number of positive responses on the long ready signal and negative responses on short ready signal.

	Actual number of coincidences	Expected by chance	Deviation	Sigma	C.R.*
L.M.	67	75	−8	6.2	−1.3
A.M.	108	100	8	7.1	1.1
J.C.	430	350	80	13.2	6.1
L.W.	111	100	11	7.1	1.6
I.H.	52	50	2	6.0	.4
C.O.	134	100	34	7.1	4.8
Totals	902	775	127	19.7	6.4

* A critical ratio of three or more, indicates that the obtained deviation from expectation cannot reasonably be attributed to chance.

J. C., a male college student, was the first observer whose scores indicated that he was reacting to our cue. On his first series he showed a tendency to respond "yes" on the long (1.3 sec.) signal, and "no" on the short (1 sec.) signal. On the fourth series this tendency produced statistically significant results. His introspections showed that he had been unable to feel any vibration or even derive any "hunches" from the vibrating instrument so that he had concentrated more on the ready signals. On the succeeding series of tests, his introspections failed to mention the signal light again, but laid his success to the fact that he was "very relaxed, and in a receptive mood."

Of particular interest was the reaction of I. H. to one series in which, unobserved by us, the contacts on our timing mechanism had become roughened so that the signal light flickered rather than producing a steady glow. The long and the short signals had a distinctive flicker. Eighty-two percent of I. H.'s responses followed the formula:—long ready signal equals "yes",

short ready signal "no." Her introspections revealed this differential flicker between the two lights. We immediately adjusted the apparatus but not without being embarrassed to think that even an experiment on incidental factors affecting psycho-physical measurements was affected by an unpredicted incidental factor.

Another fact which is interesting and has a possible significance is that with the exception of L. M.'s results, every observer showed a tendency to respond "yes" on the long ready signal and "no" on the short one. It is not unreasonable to suppose that all of the observers were in the same degree influenced by our cue. This supposition has possible support when it is further observed that, although only two observers achieved extra-chance scores, the group as a whole was significantly above chance.

Fully aware that neither the number of observers employed nor the actual results obtained warrants a conclusive statement concerning the effect of cues on psycho-physical measurements, we wish only to say that this is an indication of what might happen in the determination of thresholds. When an observer is being tested for sensory acuity, he may either be like at least three of our observers and stolidly refuse to acknowldge the stimulus until it is unquestionably present—that is he sets his criterion of sensation far too high, or he may react to what is ordinarily an inadequate stimulus and base his response on some factor having no connection with the stimulus other than temporal agreement.

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[1] Goodfellow, L. D., Factors Affecting Thresholds, (not yet published).
[2] Simpson, R. M., Effects of Muscular Tension on Visual and Tactile thresholds, doctoral thesis, Northwestern University, 1937.
[3] Goodfellow, L. D. A Psychological Interpretation of the Zenith Radio Tests of Telepathy, Journal of Experimental Psychology, Dec., 1938, 23, 601-32.
[4] Goodfellow, L. D., Heine, R. W., and Ranseen, Emil. The Significance for Psychometry of Tendencies to Follow Certain Patterns in Recording Judgments.

A Preliminary Investigation of the Types of Examination Which Provide the Most Satisfactory Basis for Giving Grades

Isabel C. Stewart and O. F. Galloway

MacMurray College, Jacksonville, Illinois

Most of the research concerning the comparative merits of the objective and the essay examination has dealt with reliability and validity. Very little research has attempted to compare the different types of examination with reference to their merits as basis for giving grades.

In an attempt to find the type or types of examination which furnish the most satisfactory basis for assigning final marks in Educational Psychology, 57 students were given an objective and an essay test on each of four units into which the course had been divided. For two of the units the objective test was given first and for two units the essay test was given first. At the end of the semester scores were tabulated as follows: total objective score, total essay score, total combined score, and total score on two objective and two essay tests. The last named combination of scores was the method previously used in the course. Letter grades were assigned on each distribution according to the Missouri Plan, and the marks thus given each student were compared. It was found that a reasonably satisfactory distribution was secured by each of the four types of scores, but the most satisfactory one was secured by the combination of scores made on two essay and two objective tests. This distribution more nearly approximated the normal, provided more decided breaks at the division points, and secured a more adequate separation of students at the two extremes. Reliability of the objective tests was $+0.84 \pm 0.03$ and of the essay tests, $+0.92 \pm 0.01$. The coefficient of correlation between essay and objective tests was $+0.81 \pm 0.03$.

A comparison of the marks assigned students on the four plans shows that 56 per cent received the same grade regardless of the plan used. It appears that the best students were best regardless of the method of measurement used, the poorest were uniformly low, and the decidedly average were average regardless of the plan by which they were measured. Students near the dividing point between two grades were likely to be near the borderline on all plans but did not always receive the same letter grade.

To secure further evidence in a course of the same general type but under somewhat different conditions, 114 students in General Psychology were given both an essay and an objective examination covering the work of an entire semester. The reliability of the essay examination was $+0.80 \pm 0.02$ and that of the objective, $+0.84 \pm 0.02$. The coefficient of correlation between the scores on the two examinations was $+0.66 \pm 0.04$. One half of the group took the objective examination first, while the other half took the essay first. Scores were tabulated as follows: objective score, essay score, and combined essay and objective score. Letter grades were assigned as had been done in Educational Psychology. Again, a reasonably satisfactory distribution of scores was obtained by all methods, but the most satisfactory one was secured by combining essay and objective scores. Of the 114 students, 54 per cent received the same letter grades on all plans. Again, it was observed that students decidedly in a grade division were usually found in the same division on all plans, while those near the division points were likely to receive different letter grades on different plans, but to remain near the borderline.

Due to the small number of subjects involved, conclusions remain tentative. The procedure is being repeated with 93 students in Educational Psychology. Conclusions tentatively reached are:

1. Either essay or objective examinations furnish a reasonably satisfactory basis for assigning marks in General Psychology or Educational Psychology, but a combination of the two types yields a somewhat better distribution of scores. This may be due to the combination scores being based on a larger number of questions.
2. A majority of students receive the same letter grade regardless of the type of examination used, and those who receive different marks are usually the ones near the borderline between two grades.

PAPERS IN ZOOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The Zoology Section carried sixteen papers and one demonstration. Eight papers are herewith published. The titles of the remaining eight and of the demonstration were as follows:

Abortive Ovogenesis in Valvata, by C. L. Furrow, Knox College, Galesburg.

A Research on the Refractiveness of the Animal Body to Certain Hormones, by Martha Scott, Southern Illinois State Normal University, Carbondale.

Relative Abundance of Species of Fresh Water Mussels, by H. J. VanCleave, University of Illinois, Urbana.

Some Parasites of Prairie Chickens of Illinois, by W. Henry Leigh, State Natural History Survey and University of Illinois, Urbana.

Biliary Tract of Hyrax, by Stewart Craig Thomson, School of Medicine, Loyola University, Chicago.

Critical Periods in Mammalian Development as Indicated by X-Ray, by T. T. Job, School of Medicine, Loyola University, Chicago.

Notes on the Ecology of Southern Illinois Salamanders, by W. M. Gersbacher and Paul G. Barnickol, Southern Illinois State Normal University, Carbondale.

Some Effects of Hormones on Maze Performance in Rats, by Eloise Pannell, Southern Illinois State Normal University, Carbondale.

Demonstration: *Color Motion Picture on the Embryology of the Pig*, by H. H. Strandskov, Univ. of Chicago, Chicago.

About 60 attended the meeting. M. T. Townsend, Illinois Wesleyan University, Bloomington, was elected chairman of the 1939 meeting.

(Signed) Paul C. BEAVER, *Chairman*.

Some Otoliths of Illinois Fishes

L. A. Adams

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All vertebrate ears have some form of material in the endolymph that serves to motivate the sensory patches of the equilibrium and hearing regions of the ear. These are usually small crystals of calcium carbonate, although sea sand is often found in the endolymph fluid of the Elasmobranchs, in which the endolymph ducts open to the outside of the head. Continuing through the vertebrates, the same system is always present, but it may take different forms in the hearing region of the ear. The lower fishes, such as sharks, have the fine carbonate crystals, while starting with the ganoids, and ending with the teleosts, there is an agglutination of the sand-like crystals into definite bodies of a larger size. These enlarged structures are found in the utriculus, sacculus and lagena. Amphibia may have otoconia agglutinated into a mass, but in birds, reptiles and mammals, there is no agglutination at all. Peculiarly, the dipnoi have masses of material but no definite otolith bodies.

An analysis of the otoliths shows that they are made up principally of calcium carbonate, with slight additions of other salts, and a small amount of organic material. Since they are attacked by acids, they disintegrate in the digestive system, are destroyed by formaldehyde and must be obtained from fresh specimens, those preserved in alcohol, or in salted specimens.

In intermediate fishes, the semicircular canals lie in the side of the brain case, and the otoliths are easily taken out by splitting the skull and taking out the brain, which leaves the canals and membraneous ear exposed. The same procedure is possible with the lower teleosts such as the Isospondyls, (trout, salmon, etc.), but in the higher teleosts, the otoliths are in such a position that the only way to dissect them out, is to slice off the top of the head, and approach them from the dorsal side. In many fishes, (Percomorphi, Ostariophysi) the sacculus and lagena lie in a tunnel which extends under the floor of the brain case, and are embedded in bone. Percomorphi have a thin bony capsule that is easily removed, but the Ostariophysi, have the otoliths in a heavy bony tunnel and in these, the best method is to remove the block containing them, and then dissolve the bone in KOH. By boiling it gently, the delicate otoliths can be removed uninjured. This method is the only safe one for the members of the Ostariophysi (carp, catfishes, characins, and electric eels).

Knowledge of the otoliths goes back to Aristotle and the early naturalists, who probably saw the otoliths in dissecting and in eating fish heads. During the middle ages, they were considered as somewhat problematical, were worn as amulets, and used in medicine. They were considered as specific for headaches, colic, kidney troubles and for other ills. Since the otoliths have peculiar markings on them, they were often regarded with superstition, and people saw in them pictures of saints, the key to paradise, and other mythical figures that lent themselves to popular superstition. The earliest anatomists considered them as structures that were highly detrimental to the fishes, and thought that they would conduct cold to the brain and thus kill the fishes in cold weather. No real work was done on the otoliths in a scientific way until the beginning of the seventeenth century, when the early students of fish anatomy began to work on the organization of this large group. The otoliths were recognized early as having some value in classification and were thus used by some of the early anatomists.

Otoliths are found in three parts of the ear: the utriculus, sacculus and lagena. The otoliths are given names according to their position in the ear. The stone from the utriculus is called the lapillus, or utriculith; that from the sacculus the sagitta or sacculith; that from the lagena, the asteriscus or lagenalith. They are placed so that they have a definite relation to the receiving macula of these ear regions. The utriculith is usually quite small, and is not as distinctive in shape as the others, although a general symmetry is always present, and it is possible to separate rights and lefts with ease. The sacculith is usually the most striking, both from its size and configuration, and the mesial face usually has a distinctive pattern, that is correlated with the receiving macula. Many points present themselves concerning this pattern on the inner face that may be used in the determination of similar forms. In most fishes the sacculith is of considerable size, as in the drums, and the weakfishes receive their generic name Otolithus, from the striking otoliths. The greatest break in the type of sacculith comes in the Ostariophysi, where the lagenalith is enlarged and the sacculith reduced to a very delicate, fragile winged spike. The lagenalith is distinctive enough so that it is possible to separate it from the others, and it is always possible to separate rights from lefts. Numerous experiments have been made to determine the use of these structures in hearing, and it is generally assumed that they act in connection with the sensory patches of the hearing part of the ear. They are held in place by slight membranes and their movements are slight. From the great variability of the otoliths it seems probable that there is some relation between the habits and type of ear structures.

The structure of the otoliths shows that it is built up in concentric layers so it is assumed that a new layer is added each year. In section these seasonal rings appear, and in many species they are quite distinct. These seasonal rings are of a different color and texture, and in a number of species lend themselves readily to age determination. In old animals the rings become somewhat blurred so that the reading is much more difficult and in this they resemble scales. In spite of some irregularities, the growth rings are of distinct value in age determination. Studies made of a long series of otoliths, of the same species, and with a wide range of sizes, show that the variability is surprisingly small. While some defective otoliths are found, they are generally true to type, and a series of a hundred specimens will show but little variation. In other words, there is little change with growth and age, and the changes in size are proportional. Otoliths differ much in their clearness, and while some are so clear that the rings are plain, others are opaque, and it is necessary to use some clearing material to make the rings show at all. Some appear to be quite chalky and rough but generally the texture is fine and clear cut.

Since there are three otoliths, there are many possible combinations, and in a systematic study of fishes, these different elements can be used very effectively. There is a wide range in shape, size, markings, and position in the skull, so that it is possible to use them in systematic work. It is at once evident that there are numerous problems that have not even been touched as to the cause of the great variation in size and shape, and also their functional significance. It seems logical to suppose that the great variation in size and shape must have some relation to the habitat in which fishes live, and to the peculiar conditions to which the different species are subjected. There must be a great variation in the needs of fishes, since in some habitats, the ear would be a most valuable sense, while in others, the value to the animal would be slight or conjectural. The fact that the sacculus usually has the largest otolith, and that it is usually more varied, appears to indicate that this part of the hearing ear is most important in fish sense reception, but a reversal of this size relation occurs in the Ostariophysi, where the sacculith is small and the lagenalith large. In this case the lagenalith appears to have the functional importance usually given to the sacculith. Some anatomists believe that the names should be reversed in this case, and that the supposed lagenalith is really the sacculith in a changed position.

The use of the otoliths in fish work has been somewhat neglected in the United States since most of the papers dealing with them are of European origin. A long series of papers by A. N. Frost made something of a survey of the whole fish group, while others on the Continent have made important contributions both in fossil fishes and in present day forms.

There is a real significance in the value of otoliths to systematic work, and it is shown that the differences in the combinations of the otoliths can be used to separate orders, families, genera and often species. An added use comes in the ability to identify the food material of carnivorous fishes and even other fish-eating animals (Cormorants and fish-eating birds, and other vertebrates). The otoliths are retained in the stomach for some time before they are destroyed by the acids, thus making food identification possible. This has been used and has proved of value to students of fish food habits. To be of value it is necessary to have large collections of otoliths identified and cataloged as one would arrange a collection of fishes for study. Small black cards to which the otoliths are attached by black celluloid are very useful. This arrangement permits classification, storage, and ready access at all times.

Much work has been done on the otoliths of fossil fishes, because certain geological horizons contain abundant specimens. It is not difficult to account for these accumulations, when one has seen some of the fish holocausts that occur so often in nature, when millions of fishes are killed, and left in windrows along the shores. With a knowledge of the modern forms, it is possible to work out fossil faunas with some accuracy, and to establish the fish horizons on a scientific basis.

Because of the structure of the otoliths and the growth by adding layers, it is possible to make use of them in age determination and for growth rate. Some fishes lend themselves easily to studies of this type, especially when the otoliths are clear or only slightly opaque. When the otoliths are chalky, grinding and sectioning must be used. With age there is a gradual infiltration and a gradual loss of the distinctness of the rings, so that the value for accurate age determination is greatly lessened.

Since there are three of the otoliths, and since the patterns of the three are quite variable, they do offer a very promising field for the study of the relationship of specie genera, families and orders. The tie that binds the Ostariophysi are certainly not apparent from the outside of the animals, although all have Weberian ossicles, but the relationship is strikingly verified however, by the types of the otoliths, which in this case are of distinctive shape, and also imbedded in the floor of the brain case.

A Statistical Approach to the Problem of Acid Secretion by the Gastric Glands*

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It was the purpose of this research to secure a large number of observations and deduce by statistical methods the answers to the following questions: (1) How do the chemical constituents containing chloride vary with the rate of secretion? (2) How do these constituents vary with respect to one another? (3) Which relationships contribute the most useful information toward answering the paramount question, at what concentration does the cell of the gastric gland secrete the hydrochloric acid?

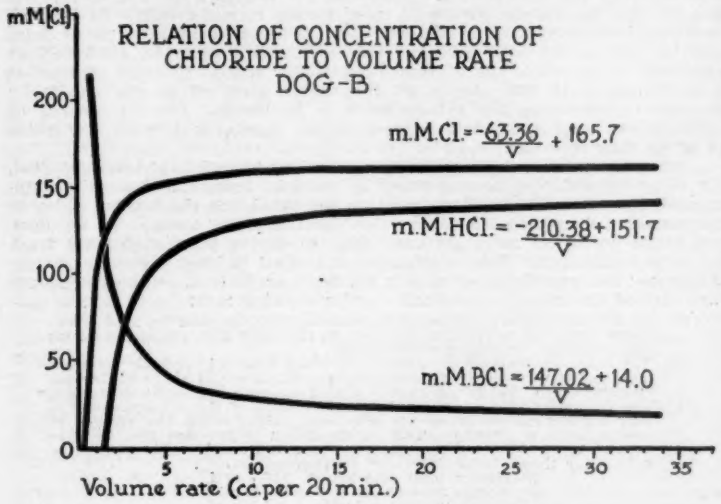

Fig. 1.

We have used dogs provided with pouches of the total stomach. The secretory stimulant was a constant amount of histamine administered subcutaneously every 10 minutes. This dose was varied during part of the work to secure all ranges of volume-rates. Collections were made every 20 minutes. Total and free acid was determined by titration. Total chlorides were determined by the Volhard titration method. The neutral chloride was taken as the difference between the total and acid chloride values.

One hundred separate samples were collected and analyzed on each of two dogs. In addition, 183 samples were collected from 6 dogs and these pooled into 9 large samples on the basis of volume-rate in 20 minutes. The data on each sample consisted of the following: neutral chloride output, neutral chloride concentration, acid chloride output, acid chloride

* Part of a complete study by J. S. Gray, G. R. Bucher and A. C. Ivy.

concentration, total chloride output, total chloride concentration, and the volume. All relationships were studied by a method of "least squares", which determined a linear equation that mathematically and graphically would express the trends of the data. The general form of the equations obtained is $y = a + bx$. The validity of these curves was measured in a degree by the probable errors of the constants a and b or by the standard error of estimate. The mathematical results of all our experiments display amazing uniformity. When the observed values were plotted about the theoretical lines, the degree of fit was most gratifying.

The outputs of both total and acid chlorides were found to increase with the volume-rate, the total chloride output increasing more rapidly. The mathematical difference between these equations expresses the relationship of neutral chloride output to the volume-rate. The neutral chloride output also increased but at a very slow rate. When all lines are extended to the volume-rate axis, meaningless values are indicated for it would appear that a neutral chloride output can exist in the absence of a total chloride output. We feel certain that at minute volume-rates, the relationships cease to be linear and deviate to describe curves that pass through the origin.

After the manner employed by Lim (1), these linear expressions were converted into hyperbolic functions expressing the relationship of concentration to the volume-rate. These curves are seen in Fig. 1 for the dog B. The asymptotic nature of these curves is self evident. If the volume-rate is extrapolated to infinity, the maximum concentration of total chloride approaches 165.7 mM and that of the acid chloride, 151.6 mM as maximum value, while the concentration of the neutral chloride approaches a minimum at 14 mM. Since all the curves level off at experimentally possible volume-rates, this extrapolation is justifiable. The significance of these curves near the origin is meaningless again, until after the point at which they intersect.

When the relationships of the concentrations to each other were studied, the results could also be expressed by straight lines. As the acidity increased, the total chloride concentration increased and the neutral chloride concentration decreased. Applying the "least squares" method to the data was found to be no more accurate than to derive the relationship from the output equations. This relationship is subject to large errors regardless of the way the equation is obtained: i.e. fitted or derived. Our experiments have yielded statistically significant results showing that:

(1) As the volume-rate increases, the outputs of total chloride, acid chloride and neutral chloride all increase in the order given, beginning with total chloride increasing most rapidly.

(2) The concentrations of the various chlorides bear a hyperbolic relationship to the volume-rate; those for total chloride and acid chloride increasing with the volume while that for neutral chloride decreases.

(3) The concentrations when studied as functions of the volume, all display asymptotic maximum or minimum values when the volume is extrapolated to infinity. This extrapolation is justified for the limits are reached at volume-rates experimentally attainable. Average values for these limits from our 3 experiments are:

Maximum total chloride	165.7 mM
Maximum acid chloride	152.6 mM
Minimum neutral chloride	13.1 mM

(4) The concentration of total chloride increases in a direct linear manner with the acidity, while the neutral chloride concentration decreases. These linear functions must be limited to the maximum and minimum values as determined by the hyperbolae obtained from the output equations. Extrapolations beyond these limits are meaningless.

Because the output studies can be manipulated to express concentration relationships as well as show the limits under which the relationships are valid and significant, we feel that the output to volume-rate studies contribute the most useful information relevant to the question; at what concentration is each of chloride constituents secreted by the cells.

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X-Rays as Causative Factors of Sex Reversal in the Developing Chick

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Introduction

Experiments dealing with the effects of X-rays on the origin and differentiation of germ cells and the formation of gonads have involved many departures from the normal course of development. Difficulties have often been encountered as to the proper interpretation and evaluation of such anomalies. Structures resembling young seminiferous tubules were found in the cortex of X-rayed ovaries. Findings of this nature have led to a closer study of the accumulated material from the point of view of sex reversal. The data are recorded in this publication.

Materials and Methods

The X-ray machine used was a Type C model, made by the Standard X-ray Company. It was mechanically rectified and provided with a Landauer roentgenometer. A Universal Coolidge therapy tube was used. The set-up of the machine for the entire experiment was as follows: The kilowatt meter was set at 96, which delivered 112 peak kilovolts as measured by the sphere gap; the milliameter was set at 6 milliamperes; the focal distance was 10 inches; the filter was equivalent to 4 mm aluminum; the roentgenometer was kept at 3.2 microamperes, which, by calculation, gave 0.6 r per second. The desired r, or dosage, was obtained by varying the time of exposure.

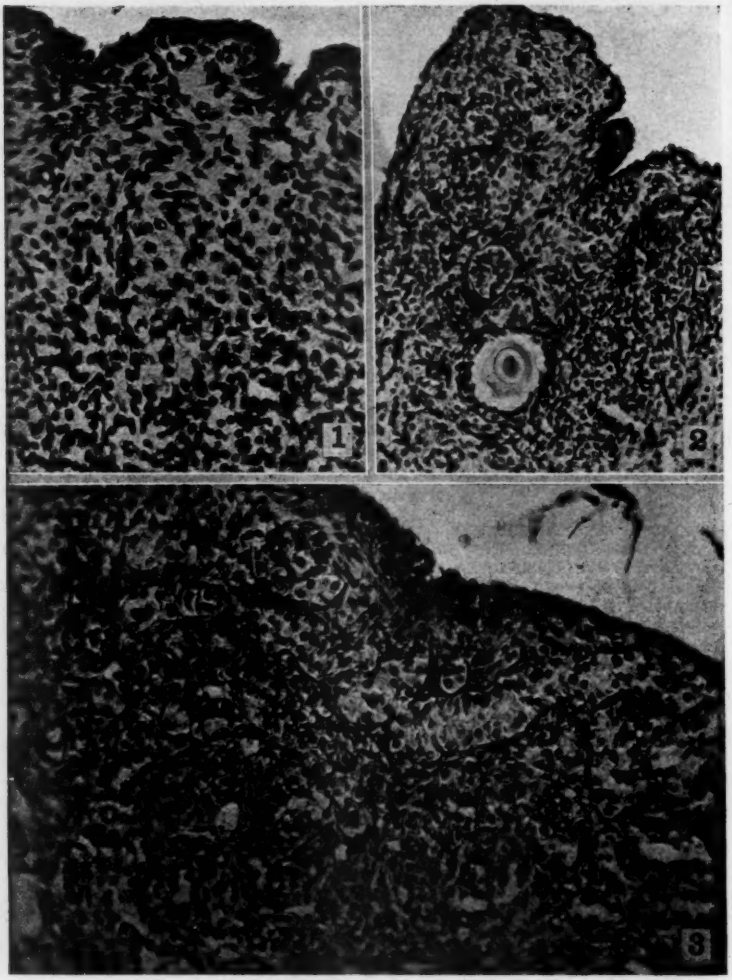
The number of specimens used for these experiments was 121. Of these, 28 were controls and 93 were X-rayed. Of the latter there were 18 eggs irradiated prior to incubation, 26 eggs treated between 5 and 12 days of incubation and 49 chicks X-rayed from the time of hatching to 21 days of age. Fourteen of the specimens irradiated during incubation received a second dose of X-rays after hatching. The dosage of X-rays varied from 40 to 600 Roentgen units. The time of preservation of the material for study ranged from the 18th day of incubation to the 22nd day after hatching.

All of the material was fixed in a solution of four parts of Kleinenberg's picro-sulphuric acid reagent and one part of 10 per cent formaldehyde. It was embedded in paraffin and stained with eosin and hematoxylin.

Results

Mitotic activity is perhaps one of the most sensitive indicators of the effects of X-rays on living tissues. In all of our material so far studied, no definite injuries on mitosis were observed with dosages between 60 to 80 r. Recovery from a temporary arrest takes place in a few hours. On the contrary, there are indications that mitotic activity is accelerated in the embryonic chick with dosages less than 80 r.

The next most sensitive structure in the chick embryo to the effects of X-rays appears to be the germinal epithelium. Initial injuries to the germinal epithelium were noted with dosages between 80 and 100 r. The proliferation of germ cells is inhibited and the fully formed germinal epithelium of two or three layers of cells in thickness returns to the original structure of the peritoneal epithelium. The germ cell content of the cor-



EXPLANATION OF FIGURES

Fig. 1. Section of an ovary of an 18-day-old chick embryo irradiated with 400 r on the fifth day of incubation. Note the scarcity of germ cells and the excessive tunica albuginea (x488).

Fig. 2. Section of an ovary of a 21-day-old chick irradiated at the seventh day after hatching with 400 r. Note atrophy of primary follicles and the abundance of testicular cords (x275).

Fig. 3. Section of an ovary of a 25-day-old chick X-rayed with 240 r at 70 hours incubation and again on the seventh day after hatching with 120 r. Note anovular follicles, testicular cords, testicular tubules and excessive tunica albuginea (x450).

tex was drastically reduced. Its place is occupied by fibroblasts in the formation of an exaggerated tunica albuginea (Fig. 1).

With dosages of 200 r or more the ova of the young follicles are so severely injured that atrophy follows. The resulting anovular follicles were found in all the ovaries of this experiment. Their further development can be divided into two stages: (1) testicular cords and (2) testicular tubules.

Testicular Cords.—During the degeneration of the ovum, the follicular cells continue to multiply and invade the space occupied by the ovum. It is likely that the absorption of the contents of the ovum is accomplished by the follicular cells. In due time, the follicle becomes a spherical mass of cells (Fig. 2). There is reason to believe that such cell masses may also originate from germ cells prior to follicle formation. This is indicated by the presence of cell masses in ovaries in which primary follicles had not formed at the time of killing of the specimen. The degeneration of ova in growing follicles has been noted in many ovaries. Their fate remains, for the present, uncertain. It is likely that they degenerate completely.

The spherical shape of the cell masses is apparently not retained for any length of time. By growth, mostly in length, the cellular masses become cords of various sizes and shapes. The testicular cords are surrounded by a connective tissue sheath which is derived from the former ovarian follicles (Fig. 2).

Testicular Tubules.—The next stage in the development of the original anovular follicles is the formation of lumina in the testicular cords. Apparently, lumina result by rearrangement of cells constituting the cords. The cells assume an epithelium-like position along-side the connective tissue sheath. In the formation of lumina, liquifaction of cells has not been noted. The testicular tubules were found almost exclusively in ovaries that received a double innervation (Fig. 3).

Discussion

Testicular cords have been found in all of the ovaries that were severely injured by X-rays. Definitely formed testicular tubules occur in double irradiated ovaries that had received at least 300 Roentgen units of X-ray. These structures were found in the cortex of the definitive ovary.

By histological criteria the testicular tubules are readily comparable to the seminiferous tubules of the chick shortly after hatching. The developmental history of the testicular tubules resembles that of the seminiferous tubules. A third male characteristic is the greatly enlarged tunica albuginea found in severely injured ovaries.

It is possible that sex reversal in the developing chick can be induced experimentally by means of X-rays. However, the problems cannot be solved on histological data alone. The findings must be verified in the living chick before any definite statement can be made.

That sex in animals is not irrevocably set at the time of fertilization is now recognized by all students of sex problems. Partial sex reversal occurs spontaneously in many groups of animals including man. The literature dealing with sex reversal in the domestic fowl is abundant but only a few publications can be mentioned here.

Sporadic sex reversal in the chicken has been reported by Dent (1), Berner (2), Crew (3) and Hartman and Hamilton (4). These reports deal with adult chickens in which the changes are in the female-male direction. The factors underlying such changes have not been definitely determined. In some instances pathological destruction of the ovary has been found and thus interpreted as the cause of sex reversal. Histological studies of such birds have revealed the formation of seminiferous tubules in the diseased ovary or the rudimentary right ovary: Boring and Pearl (5), Fell (6) and Mackling (7).

Attempts have been made to induce sex reversal in the domestic fowl experimentally. Two methods have been used: ovariotomy and sex hormones. Ovariotomized young female chickens have developed testis on one or both sides. In some instances apparently normal spermatogenesis was observed: Goodale (8), Zawadowsky (9), Benoit (10) and Domm (11). By the use of the male sex hormone partial sex reversal has been induced in the chick embryo. Seminiferous tubules were obtained in the definitive as well as the rudimentary ovary, Willier (12).

Summary

1. Initial injuries to the ovarian follicle result in all ovaries irradiated with 200 or more Roentgen units.
2. Major damage to the ovary is caused by double irradiation.
3. The ovum of the young follicle is affected first, it atrophies and the cavity is filled with follicular cells.
4. The resulting cell masses are found in the cortex of ovaries irradiated with 200 or more r units.
5. Testicular cords develop from the spherical cell masses.
6. Testicular cords become tubules by the formation of a lumen.
7. The tubules so formed have a marked resemblance to the seminiferous tubules of the young chick. The developmental history of the two structures is similar.
8. The development of an extensive tunica albuginea adds a third male characteristic to the X-ray injured ovary.

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Differential Modification of Embryonic Development of Organs in Twins and Double Monsters of Salt-Water Minnows

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This paper is supplementary to one which recently appeared in *Physiological Zoology* (Vol. XI, 2), and is the fourth in a series of studies with ultraviolet radiation and fertilized Fundulus eggs. The radiation source was a Cooper-Hewitt quartz mercury-vapor arc. Eggs were exposed for varying periods of time at intervals shortly after fertilization.

In singly developing axes, the most frequent modification appeared in regions of the body, which at the time of exposure were physiologically more active in relation to other regions. In this way varying degrees of reduction in the developmental potency of the anterior median region appeared.[1]

Similar effects may be obtained when early exposures made just prior to the first cleavage result in the development of two axes with consequent production of twins and double monsters. Each member of such a pair may be independent of the other, or the two may be united posteriorly and show varying degrees of normality of development. In the above instances, each member usually has its own circulatory system with a heart whose rate of beat seems to be a function of its relative normality, i. e., two hearts may beat at different rhythms on the same yolk sac.[3]

Such embryos may be antipodean in their positions on the yolk sac, and be entirely unconnected anatomically and appear not to influence each other's growth. Microscopic examination of such embryos reveals complete mirror imaging of parts.[2]

On the other hand, where developing axes are anatomically connected, and one seems to have a developmental advantage at the outset, they appear to influence each other physiologically, and within a short time it becomes evident that one embryo is growing at the expense of the other. The result is that one embryo may be completely normal and its smaller partner be differentially inhibited. The inhibition of development manifests itself in the same way as the inhibition which appears in single axes, but since the inhibiting agent (in this case the other member of the pair) is continually present, the degree of inhibition is definitely more marked and its effect continuous and uncomplicated by differential recovery.

When these embryos are sectioned and studied microscopically certain facts are evident, namely, the central nervous system is most frequently inhibited particularly in the region of the developing forebrain. In some instances, differentiation seems not to have kept pace with proliferation, with the result that a large amount of brain tissue develops without any characteristic brain structure. In such an embryo the rest of the organs appear to develop normally in most instances. A similar condition has been previously reported in chick embryos.[4]

In some double monsters the development of both embryos is inhibited. Microscopic study of these forms reveals the same selective inhibition along developmental axes. In some extreme cases, namely, in the autosite-parasite type only a small protoplasmic mass appears in place of a second embryo. Study of sections of such an inhibited member may show little more than a heterogeneous mass of commingled tissues which can scarcely be distinguished from each other and in which a directional developmental force is obviously lacking. Such a form may or may not have its own yolk sac circulation. A hormonal influence on development appears to be ruled out

in the former instance. Furthermore, the inhibitory effect is obviously already active at the time of early development of the nervous system, i. e., before the circulatory system becomes active.

In many instances, in the development of closely adjacent parallel axes, a mid-line fusion is obvious in the central nervous system and frequently the only evidence of duplication appears in the single posterior axis, as a ventral bifurcation of the neural canal, and a double notochord.

In conclusion it may be stated that where developmental inhibition of embryonic axes is produced by early exposure to ultraviolet radiation, the developing nervous system, in most instances, shows the greatest degree of modification.

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On the Path of the Firefly While Periodically Flashing

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A good deal has been written on the life history of the firefly, and many, including physicists and chemists, have speculated on the efficient light that these small insects can turn on and off at will. It is not the writer's intention to say anything regarding the former, for he is not a zoologist, or anything regarding the chemical and physical aspects in the production of the light, but he does wish to call attention to one of the firefly's instinctive qualities, namely, to its path in flight while periodically flashing. A fairly complete search through the literature for discussions on this point has been made without much success.

The writer was reared on a farm in the "Big Woods" of northwestern Ohio at a time when nature there was still in its unspoiled state, for three-fourths of the area was forest. He remembers as a boy a field of about ten acres, recently cleared, lying alongside of the road and adjacent to his

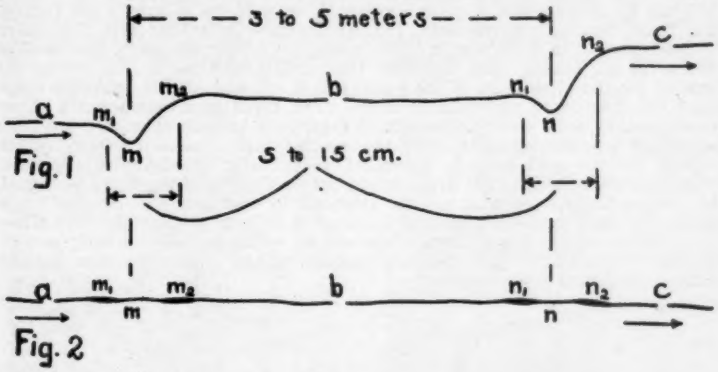

Fig. 1

Fig. 2

father's place. We often drove along this road at dusk and with wonderment observed the myriads of fireflies moving about over this newly cleared, but not yet broken, field. The soil conditions, the humidity, the decaying stumps and new undergrowth must have been favorable for their existence and propagation. It was in this field that the writer first observed the actual path that the firefly traces in flight while flashing periodically. He has observed this same characteristic path down through the years, and only last summer checked it again. It should be stated that numerous persons have been interviewed, including zoologists, chemists, physicists, physiologists and psychologists and the first has yet to be found who definitely stated having noticed the recurrent irregularities in the flight of the firefly at the time of flashing.

A brief description and discussion follow: The firefly on its twilight excursions flies for the most part in a horizontal direction. Take a windstill evening. A trace of its path viewed horizontally and from the side is shown in Fig. 1.

The portions *a*, *b* and *c* represent the more or less undulating stretches of flight of the fly, while m_1, m, m_2 the path during a "flash", and n_1 n, n_2 the path during the next following flash. As viewed from the side the fly on approaching m_1 slows down appreciably (seeming to waver slightly as if in an effort to stop) but maintains its flying level. The light then goes on and simultaneously the firefly drops visibly from its horizontal flight, but acceleration at once ensues, the downward duck is quickly arrested followed by an upward spurt as shown by the trace m m_2 in the figure. On reaching m_2, at a distance of from 5 to 15 cm from the beginning of the flash, the light is suppressed and simultaneously the flight is again slowed down. The firefly seems to waver, as in an effort to regain its equilibrium, before continuing its more or less undulatory flight along *b*, reaching n_1, when the luminous path cycle is repeated.

Looking down from above, (Fig. 2) the path discloses no outstanding characteristics. The direction of flight is pretty much straight ahead, but on close observation there may be seen at times signs of wavering at points m_1 and m_2 and also at n_1 and n_2, referred to above and shown in Fig. 2 by the thickened portions of the line. Observations from above reveal the accelerations in flight, both positive and negative, over the flash period. These observations are not, however, easy to make, as one can well imagine.

Speculating on the evidence revealed by the foregoing, it seems that the system (the firefly) may be thought of as containing stored energy under control of the insect for both maintaining flight and producing flashes of light. The fly now contemplates a flash as it approaches, say, m_1. On turning on the light (drawing energy from the common source) the attendant "overload" causes the mechanism necessary for sustained flight to slow down and the fly drops slightly. Simultaneously extra stores of energy are tapped, the flight mechanism responds, the illumination brightens and the insect speeds upward, in its endeavor to overcome the falling tendency, and reaches the point m_2, having thus described the smooth path m_1 m m_2. At m_2 the energy for the production of the light is shut off, and with it doubtless some that was needed in maintaining flight. The flight mechanism again slows down, the fly may waver as though to regain its balance (Fig. 2), and then starts off at reduced speed over the routine flight between flashes, while energy for the next flash is generated (chemically or otherwise) enroute. That considerable energy is expended in the production of the flash, and must be renewed (between flashes) is evidenced by the fact that if the fly is caused to emit light continuously its brightness dims perceptibly with time.

The above are the writer's observations, extending over a long period. Figure 1 depicts the path quite accurately. Have other observers noticed similar persistent irregularities?

An Anomaly of the Venous System in a Cat, Showing Paired Superior and Inferior Vena Cavae

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A mature cat, dissected in 1932 by Mr. Clark as a part of the laboratory work in Comparative Anatomy, was found to have an interesting anomaly of the systemic veins. From the ventral side (Fig. 1) the ventricles and auricles of the heart appear to be normal. Just anterior to the right auricle there is a rather large, blood-filled sac which is formed by the union of two large veins. One of these veins passes anteriorly as a right superior vena cava with normal branches. The other passes posteriorly as a combined azygous and right inferior vena cava. After passing through the diaphragm it goes into the posterior end of the body receiving normal veins from the right side of the body. There are, however, no hepatic veins emptying into the inferior vena cava. On the left side of the heart a superior and inferior vena cava can be seen. These unite at about the level of the auriculo-ventricular groove to form a large blood-filled sac. The

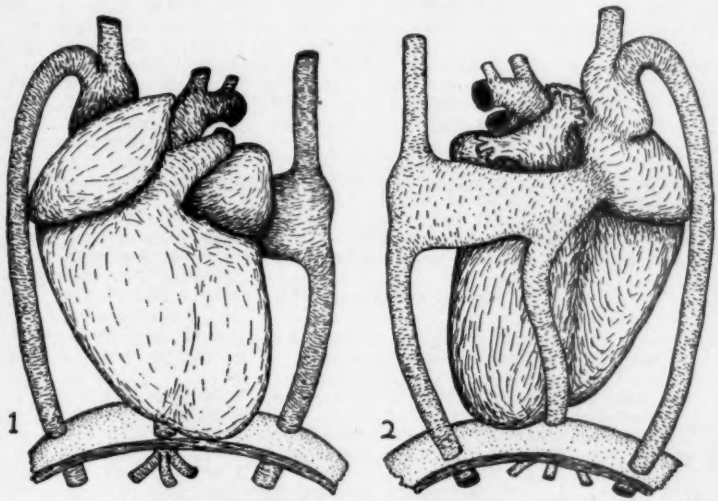

Fig. 1. Ventral view of the heart of cat.
Fig. 2. Dorsal view of the heart of cat.

blood vessels entering the two left vena cavae are similar to those on the right side of the body. Hepatic veins unite to form a common hepatic which passes through the diaphragm and disappears dorsal to the heart.

From the dorsal side of the heart (Fig. 2) it can be seen that these two sacs do not unite but empty into the right auricle by separate openings. The right sac empties into the auricle near the middle of the anterior border. The left sac lies on the dorsal side of the heart in the auriculo-ventricular groove and enters the auricle at the lower left corner. Near the median line of the heart the left sac receives the common hepatic vein.

This anomaly is evidently due to the arrested development of certain blood vessels in the fetal life of the animal. The systemic veins are practically bilaterally symmetrical, resembling those found in the lower vertebrates or in the early stages of fetal development. It seems probable that during fetal development the anterior cardinal veins failed to anastomose and form the left innominate vein. In the abdominal region the right and left subcardinals also failed to anastomose. These, combined with parts of the postcardinals and supracardinals, must have developed into the right and left inferior vena cavae found in this cat. As a result the absorption of the sinus venosus and ducts of Cuvier was incomplete and their remnants remain as the two pouches formed by the union of the superior and inferior vena cavae. The left duct of Cuvier has not been reduced to a mere coronary sinus, but is retained as a large functional vessel. The caudal extension of the hepatic veins evidently failed to anastomose with the subcardinal and umbilical veins so the common hepatic vein passes into the remnant of the sinus venosus on the left side.

A Report on the Earwig *Doru aculeatum aculeatum* (Scudder), from a Marsh in Northern Illinois

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Doru aculeatum aculeatum (Scudder) is one of the three earwigs found in northern Illinois, other than adventives, of which *Doru lineare* (Escholtz) has been reported at Urbana on cabbage shipped from Texas. *Labia minor* (Linn.) is another of the three, and I have found it flourishing at Ottawa. One evening (June 28, 1936) I took twenty specimens at a light, and I have found six specimens since then.

Doru aculeatum aculeatum (Scudder) is a distinctly marsh species. It was reported by Thomas (1876) from northern Illinois, but has not been taken from the State since then, as far as is known.

I have taken this species in and near a marsh across the Illinois River from Starved Rock State Park. Being permanently wet, but shallow, this marsh is an ideal location for most prairie marsh fauna and flora. It is a typical virgin marsh for Illinois. In the deeper portions is a good stand of Blue Flag, mixed in with Cat-tail.

Most of the specimens were taken by Mr. Charles J. Alikonis of Ottawa and myself from under boards and logs along the border. They became more common on approach to the border, and were found very common on it. None were found over fifty feet away.

In early summer specimens were found on the blossoms of the blue flag and crawling over the other vegetation. They seemed to be feeding on either the pollen or the corolla of the blue flag. When disturbed they "dropped", this making them very hard to collect, especially since the water and mud were almost to one's knees in places.

This species is nocturnal in habit. Specimens kept in captivity were very active at night, but hid when light was placed upon them, as they also did during daylight. They make full use of the stink-glands on top of the abdomen, creating quite an odor when a hundred or so are concentrated and disturbed.

All of the specimens taken are brachypterous, and in all those examined the wings are much aborted. The size varies in the male from 13.25 mm. to 20 mm., and in the female from 12 mm. to 16 mm., all measurements taken from the front of the head to the tip of the forceps. It is a queer fact that the larger males have the best-developed forceps, while the smaller ones invariably have slender ones, sometimes wholly untoothed. The females are very uniform.

Following is a record of the specimens taken:

(hibernating)

May 15, 1936	C. J. Alikonis.....	1 male	
Feb. 28, 1937	F. G. Werner.....	9 males,	10 fem.
	C. J. Alikonis.....	4 males,	17 fem.
Feb. 11, 1938	F. G. Werner.....	53 males,	42 fem.
Feb. 12, 1938	F. G. Werner.....170	males,	260 fem.
	C. J. Alikonis.....	18 males,	27 fem.
Feb. 13, 1938	C. J. Alikonis.....	1 male	
Feb. 26, 1938	F. G. Werner.....	1 male	

(on Blue Flag, and crawling over vegetation)

June 3, 1937	F. G. Werner.....	6 males	
	C. J. Alikonis.....	4 males,	2 fem.
June 13, 1937	F. G. Werner.....	7 males	

Many were seen dead, possibly due to the cold or to the fact that the land was burned over in the fall.

A short series was sent to Dr. Morgan Hebard for determination, and he verified it as this species.